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VALIDATING A SOCIAL MODEL WARGAME: AN ANALYSIS OF THE GREEN COUNTRY MODEL

by

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Modern most wargaming models are a simulation of large force-on-force conflicts, and are not capable of articulating social factors of the society being modeled. The Green Country Model (GCM) was established as a two-player wargame utilizing unconventional and irregular warfare tactics, taking in consideration the effects of social factors on the population and stability operations of the regions (winning the "hearts and minds" of a society). The game is not meant to offer predictions for a course of action or the impact of a course of action on the future, but to provide players, particularly those players who are leaders, a forum in which to discuss strategy, tactics and possible courses of action, thus improving the knowledge base and ability to "think outside the box" concerning various regions. Utilizing the concepts, input parameters, and underlying algorithms established by Johns Hopkins University Applied Physics Lab, we build a simulation model to begin the validation process of the GCM. This model, which can run one action in thousandths of a second, will not only provide developers a framework for continued validation, but can provide users and policy makers training opportunities while would aid in decision-making.

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VALIDATING A SOCIAL MODEL WARGAME:
AN ANALYSIS OF THE GREEN COUNTRY MODEL

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ABSTRACT

Most modern wargaming models are a simulation of large force-on-force conflicts, and are not capable of articulating social factors of the society being modeled. The Green Country Model (GCM) was established as a two-player wargame utilizing unconventional and irregular warfare tactics, taking in consideration the effects of social factors on the population and stability operations of the regions (winning the "hearts and minds" of a society). The game is not meant to offer predictions for a course of action or the impact of a course of action on the future, but to provide players, particularly those players who are leaders, a forum in which to discuss strategy, tactics and possible courses of action, thus improving the knowledge base and ability to "think outside the box" concerning various regions. Utilizing the concepts, input parameters, and underlying algorithms established by Johns Hopkins University Applied Physics Lab, we build a simulation model to begin the validation process of the GCM. This model, which can run one action in thousandths of a second, will not only provide developers a framework for continued validation, but can provide users and policy makers training opportunities while aiding in decision-making.

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LIST OF ACRONYMS AND ABBREVIATIONS

acteff	action effect
Avg	Average
DIME	Diplomatic, Intelligence, Military, and Economic
DoD	Department of Defense
FCA	Federal Capital Territory
GCM	Green Country Model
GoN	Government of Nigeria
GUI	Graphical User Interface
HUMINT	human-sourced intelligence
IMN	Islamic Movement in Nigeria
IO	Information Operations
IW	Irregular warfare
JHU-APL	Johns Hopkins University-Applied Physics Lab
MEND	Movement to Emancipate the Niger Delta
M&S	Modeling and Simulation
NC	North Central
NE	North East
NGO	Non-Government Organization
NW	North West
NPA	Non-Player Actors
Pe	Permission
PMESII	Political, Military, Economic, Intelligence and Infrastructure
Pr	Proxy
RNG	random number generator
SE	South East
SME	Subject Matter Expert
SS	South South
Std Dev	Standard deviation
SW	South West
U	Unilateral
VV&A	Verification, Validation and Accreditation

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EXECUTIVE SUMMARY

The Green Country Model (GCM) developed at Johns Hopkins University-Applied Physics Lab (JHU-APL), was contrived to determine if the social aspects of a society could be incorporated into a wargame in order to simulate realistic outcomes of an event or action of a player whose opponents range from friendly to hostile. The game is not meant to offer predictions for a course of action or the impact of a course of action on the future, but to provide players, particularly those players who are leaders, a forum in which to discuss strategy, tactics and possible courses of action, thus improving the knowledge base and ability to “think outside the box” concerning various regions.

The GCM is a vast model originally built on 19 intricately linked and embedded Microsoft Excel spreadsheets. With the current model, it takes about a day for the players and moderators to get through all the phases of the game. The game was built as a two-player (or two-group) board game, with a simple Graphical User Interface (GUI), which projects maps and spreadsheet displays onto a screen in order that players can get a bigger picture of the game set-up. The analysis of several actions can take the moderators from one to two hours, depending on the actual number of actions the players selected.

To speed up the process, we build a simulation model that utilizes random numbers to select all of the options that are normally chosen by the players. The spreadsheets and the embedded equations were analyzed, dissected and written into 30,000 lines of Java code. The resulting model required no human input, and can run one action in thousandths of a second. In this thesis the random operations of the model (of which there are dozens) are all specified by random numbers generated from user-selected distributions. In this way, we allow the model to be vastly more general, and useful for much more than simple two-group play. This should allow players, developers, analysts and policy makers the ability to assess and quantify the possible effects of choices (and the probability distributions of outcomes associated with those choices) in a way that has not been possible before this analysis.

The vast size and number of parameters in this model make it impossible to validate in one study. However, we believe that our study provides a good initiation into the validation process, and the framework developed could be utilized and built on, to run thousands of other simulation tests and continue the validation process.

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I. INTRODUCTION

A. OVERVIEW

Beginning with conflicts in Afghanistan, Iraq (in particular, post-conflict operations) and various ungoverned African nations (e.g., Somalia), the United States Military has seen a transformation in its mission from conventional warfare to irregular and unconventional warfare. Irregular warfare (IW) is a struggle, often violent, among state and non-state actors, in an attempt to gain legitimacy and influence over the population's beliefs (Department of Defense [DoD] Directive 3000.07, 2007). It emphasizes the use of irregular forces as well as indirect methods to defeat and or exhaust the enemy; tactics include attrition, exhaustion, and subversion, rather than direct force-on-force conventional confrontations (Larson, Eaton, Szayna, & Nichiporuk, 2009, p. xii). The Department of Defense is actively seeking innovative ways to deal with and combat irregular and unconventional warfare. One approach could be in the form of wargaming. A wargame is a model or simulation not involving actual military forces, in which the flow of events is affected by, and in turn affects, decisions made during the course of those events by players representing opposing sides (Perla, 1990, p. 274).

Most wargaming models are a simulation of large force-on-force conflicts, and are not capable of articulating social factors of the society. The Green Country Model (GCM) was established as a two-player wargame utilizing unconventional and irregular warfare tactics, taking in consideration the effects of social factors of the population and stability operations of the regions (winning the "hearts and minds" of a society). "Stability operations" have been suggested to be a key to the success of the U.S. military and irregular warfare. "Stability operations" is defined by the Department of Defense as an overarching term that encompasses military missions, tasks and activities conducted outside the United States. Their objective is to reestablish or maintain a safe and secure environment, and to provide essential governmental services, emergency infrastructure and reconstruction, and humanitarian relief (DoD 3000.05, 2009, p. 1).

The GCM developed at Johns Hopkins University-Applied Physics Lab (JHU-APL), was contrived to determine if the social aspects of a society could be incorporated into a wargame in order to simulate realistic outcomes of an event or action of a player whose opponents range from friendly to hostile. The game is not meant to offer predictions for a course of action or the impact of a course of action on the future, but to provide players, particularly those players who are leaders, a forum in which to discuss strategy, tactics and possible courses of action, thus improving the knowledge base and ability to "think outside the box" concerning various regions. This can, hopefully, improve their understanding and possibly aid in the decision-making process in the area of interest. The GCM has been utilized by numerous military and civilian groups, and has been through one verification effort, which studied and tested the analytic rigor of the model output (Simpkins, Ihde, & Haney, 2010, p. 3). As of 2012 there have been no attempts at validation or accreditation of the model. Verification is the process of determining that a model accurately represents the developer's conceptual description and specifications. Validation is the process of determining the degree to which a model is an accurate representation of the real world from the perspective of its intended use(s) (DoD MIL-STD-3022, 2008, p. 3). Through the course of this study, the GCM will be analyzed on both a microscopic and macroscopic scale in order to provide a degree of validation and verification of the model and define its potential as a training tool. This process will ensure that future users understand the limitations of the model and what it can bring to the fight.

B. LITERATURE REVIEW

The literature on the construction and use of socio-behavioral models like the GCM is sparse. We have not found an extensive treatment of the gaming approach based on, for example, sociological or psychological principles. Available models are generated based on reasonable heuristics, but no such model appears to have been validated to any real degree.

In this section, we review some of the literature regarding the DoD requirements for simulation modeling, validation and verification. We briefly examine social models, as distinct from other types of models, and address the lack of an established process for validating them.

1. Military Simulation, Verification and Validation Requirements

The Department of Defense has documented a framework for the verification, validation and accreditation (VV&A) of models and simulations (DoD MIL-STD-3022, 2009). This paper provides the definitions of verification, validation, modeling and model simulation as they apply to the DoD. Additionally it provides an outline for the requirements for the verification and validation process. The document does not, though, prescribe specific steps required in these processes. This thesis incorporates some of the requirements necessary for a full validation of a DoD model. However, many of the requirements listed remain to be met, as this thesis provides only a portion of the validation and verification process of the GCM.

DoD's Directive 5000.59 (DoD 5000.59, 2007) is entitled "DoD Modeling and Simulation (M&S) Management." This paper serves to address the issue of the importance of simulation models to the DoD and the goals of developing a simulation model: "promoting visibility and accessibility of models and simulations; leading, guiding, and shepherding investments in M&S; assisting collaborative research, development, acquisition, and operation of models and simulations; maximizing commonality, reuse, interoperability, efficiencies an effectiveness of M&S, and supporting DoD Communities that are enabled by M&S" (DoD 5000.59, 2007, p. 2). It does not, however, provide specific guidelines for the practitioner.

2. Social Models

Pew and Mavor (1998) gives insight on what type of simulation models the military would be interested in utilizing. Although they mention behavior models specifically, the models available to them were quite different from the models of today. JHU-APL personnel developed the actual concepts and criteria of how they desired to model human behavior in GCM, but the implementation of GCM in this thesis was developed using many of the concepts mentioned in Pew and Mavor (1998). For example, the ability to represent the behavior of individuals, as well as teams and larger organizations, was captured by giving the moderators the ability to change the amount of resources allotted to players. That is, the moderators can change the amount of power a player has, to ensure that player can only perform actions appropriate to that player's skill level and influence.

Pew and Mavor (1998) also emphasize the importance of a behavior model and its ability to represent real-world behavior under different conditions, which is part of the analysis process in this thesis. The authors stress that there are many types of behavior models that are important to military users, including training simulations (whose users might be instructors or those being trained); mission rehearsal simulations (used by operational forces to prepare for specific missions); and analysis simulations (whose users might evaluate, for example, policy choices). The model built for this thesis is built to support users of all of these types of simulations.

Pew and Mavor (1998) also list numerous human behavior models in use by the military as well as some of their limitations. Interestingly enough, none of the models listed actually incorporate human behavior to the degree of the GCM. The authors note that what they call "human behavior in constructive wargaming models" incorporates human decisions by inserting a doctrinally based decision rule for what an individual ought to do; performance capacities and limitations are ignored. It goes on to state that human behavior models are in the infancy stage but are "badly needed" to create realistic and useful evaluations. (Pew & Mavor, 1998, p. 44). The GCM does not insert an actual pre-established behavior; it produces behavior data, in accordance with subject matter experts' opinions, which result from an action. The next decision is then based on the resulting behavior.

Alexander, Ross, Vinarskai and Farr (2012) emphasize the difficulties of incorporating social aspects in a computerized wargame. They note: "for a wargame to be useful to the military, it must closely approximate as many of the elements of war as possible. Among the elements that are typically not modeled or are poorly modeled in nearly all military computer-based wargames are systematic effects, command and control, intelligence, morale, training, and other human and political factors" (Alexander et al., 2012, p. 94). "Strategies for achieving victory over an opponent often rely on adversely impacting the psychological and emotional state of that opponent. However, as previously mentioned, most simulations of warfare do not attempt to incorporate these soft factors and, instead, choose to model victory only by attrition" (Alexander et al., 2012, p. 95). The GCM's goal is to successfully incorporate "soft" factors into a wargame. The goal of this thesis is to computerize the individual actions of the wargame in order to allow it to be run many times. This is turn can help us understand how the social factors interact and whether they are effectively capturing the behavior of a society. We use simulation to examine the behavior of the GCM when it is played repeatedly with differing choices. Because the GCM focuses on behavior and social aspects of a society, it is quite different from the usual simulation models of, for example, discrete events. There is an extensive literature on this sort of simulation (for example, Kelton, Sadiwski, and Sadowski, 1998, describe a number of modeling approaches using a particular piece of software).

A number of social models appear to be being built, but very few seem to be widely used, perhaps because of the difficulty in validating them. One recent effort at validation comes from Marlin (2009), who used the Peace Support Operations Model PSOM model as a starting point for a simulation of a specific mission in Iraq. He attempted to validate the PSOM using designed experiments together with simulation in an effort to run real-world scenarios, with an analysis of the data focused on three doctrinally essential measures of effectiveness (obtained from the local Sunni population) provided by PSOM in an Iraq based scenario. Our thesis is different in that it is not based on a real-world scenario; in fact, that would be the logical next step for the GCM simulation model. The GCM simulation model we built removes the human-in-the-loop requirement, and allows for multiple potential outcomes in order to detect anomalies and examine the variability of results.

3. Validation of a Social Model

The validation of a social model is largely undefined. There are numerous ongoing attempts to build an adequate, useful social model. However, the lack of an accepted validation process for these models continues to impede universal acceptance of any of them. Goerger (2004) set out to examine the extent to which human behavior models can be validated. He notes that validating physics-based models is well-defined using long-established standards. However, the process of validating behavioral models is not as well-defined. The validation process developed, matured, and refined over time for physics-based models is not well suited for validating behavioral models (Goerger, S.R. 2004, p. 2).

In this thesis we validate not the computerized simulation model, which acts as a "wrapper" for GCM, but the GCM's ability to realistically represent the expected results of human actions in a society. While it is difficult to represent the "change in affinity between action requestor and government as a result of an action," for example, in a mathematically precise way, our results indicate the model produces changes in the expected direction and of reasonable size. The model created in this thesis is a tool that was developed to study thousands of simulations of the GCM and to provide a framework in order to analyze the output. The literature review on this topic has demonstrated the enormous need for such a model, as well as the shortfalls and lack of validated models in existence. Army Colonel Wm. Forrest Crain has said that "The reason those [existing social] models didn't work was because they couldn't properly simulate human behavior. The next generation of simulations will need to address the 'representation' of human behavior…we've barely scratched the surface" (quoted in Erwin, S.I., 2000, p. 1). This thesis is based on requirements set forth in numerous DoD publications on validation and verification as well as the military requirements desired for a social model that can capture human behavior as it parallels real life events, thus aiding in the training and the decision making process.

C. BACKGROUND

The United States military must maintain the ability to fight a large-scale traditional war; however, its mission now encompasses fighting small-scale unconventional wars in highly divergent societies. The difference between the two types of warfare is that in traditional warfare the objective is to defeat an adversary's forces, destroy its war-making capacity and seize or retain territory in order to force a change in an adversary's government or policies (DoD, 2007, p. 19). The United States invasion of Iraq, where the goal was to remove Saddam Hussein from power and establish a new government is an example of this type of warfare. Irregular warfare encompasses unconventional warfare. Unconventional warfare's spectrum of military and paramilitary operations are normally of long duration, and conducted through, with or by indigenous or surrogate forces who are organized, trained, equipped, supported and directed by an external source. It includes guerrilla warfare, sabotage, intelligence activities and assisted recovery (DoD, 2007, p. 19). Current activities of United States forces in Afghanistan can be considered unconventional warfare; it is a conflict directed against non-state actors, not the country of Afghanistan. Traditional warfare has been well documented and modeled over the years; this is not the case for unconventional warfare, which has emerged as the dominant type of warfare only over the last ten years. The National Military Strategy of the United States of America, signed by Chairman of the Joint Chiefs of Staff, Admiral Mike Mullen in 2011, suggests the changes that the United States military needs to undergo and in fact begins to address how the United States can fight unconventional wars. He emphasizes the theory of utilizing the strength of our military, specifically its strong leadership, adaptive diplomacy, and ability to evolve to reach its maximum capacity of power in defense of our national interests. The military should, according to Mullen, leverage its forward presence and focusing on building relationships, supporting host nation values and utilizing military capabilities to deepen security ties and act as a security guarantor. These tactics will aid in preventing attacks against the U.S., strengthen our international and regional security and prepare us to deter and defeat aggression, either alone or with partners and allies (Mullen, 2011, p. 1).

In these constrained fiscal times, the DoD is continuing to seek out cost-saving initiatives in the area of training, and are encouraged in DoD Directive 1322.18 to utilize alternative methods to improve training while still remaining as efficient and effective as possible: "[m]embers of the Department of Defense shall receive, to the maximum extent possible, timely and effective individual, collective, and staff training, conducted in a safe manner, to enable performance to standard during operations. Live training resources shall be sustained through good stewardship, public outreach, comprehensive planning, and the leveraging of advanced technologies. Training realism shall be maximized through use of the live training domain supplemented by integrated virtual and constructive capabilities. Cultural awareness and language training shall be embedded in accession training, professional military education, and pre-deployment training and integrated across the Total Force" (DoD Directive 1322.18, 2009, pp. 2 and 3). This directive continues on, encouraging new technologies and innovative thinking in order to accomplish its goals. The DoD shall "[c]oordinate with the experimentation and test communities to anticipate and implement training capabilities supporting new or improved war-fighting capabilities" (DoD Directive 1322.18, 2009, p. 7). Human dynamic models on a national scale could be the answer the DoD has been seeking; these are high-quality models that could improve the nation's ability to manage social and political conflicts. A successful, realistic model could assist in winning counterinsurgency battles, improve peacekeeping missions, provide better understanding of asymmetric warfare and its impact on social values and possibly even prevent conflicts before they begin. Such a model could be utilized by leaders, both military and civilian, to understand adversaries and civilian populations, thus improving how the military conducts business as well as possibly improving research, establish policy, and conduct training (Bos, Greenberg, Kopecky, Ihde, & Simpkins, 2011, p. 1). Johns Hopkins University Applied Physics lab developed the GCM in an attempt to capture the effects of social influence and affinity on a region and its people. It attempts to demonstrate how civilian or military forces can take actions that will impact not just the people of the region, but its politics, military, economy, social empathy, media, and infrastructure. This thesis provides some validation and verification of the model, and in doing so answers some critical questions concerning the model's parameters.

D. RESEARCH QUESTIONS

- What individual parameters are required and how are they captured in the model? What are the current and programmed capabilities of the parameters?
- What parameters are needed for the model to perform accurately?
- What is the desired outcome? What are the minimum essential tasks to perform in order to accomplish the mission or achieve effects, under what conditions, and to what performance standards?
- What are the gaps, shortfalls, or redundancies that exist in the model, under the identified conditions, compared to the identified performance standards?
- What are the intended parameter interactions and does output data from the GCM verify performance? How does factor significance and weighting affect results?

E. BENEFITS OF STUDY

The focus of this study is to provide model some validation and verification for a wargame which could assist in examining scenarios pertaining to unconventional and irregular warfare prior to actual "boots on ground" military action. With continuing financial constraints this model could provide tactical experience, test practices and procedures and develop emergent concepts of possible volatile operations at comparatively low monetary and human costs.

F. METHODOLOGY

In order to completely understand and determine a model's value, capabilities and effectiveness it requires thorough Validation and Verification. This study serves to provide a portion of the validation process and will help to assess the capabilities of the GCM and its ability to deliver effective training, planning and course of action analysis to its users. Verification requires an analysis of the relationship affinities of the input parameters, and whether the model produces realistic and accurate outputs. In this study numerous simulations of the possible actions were examined; quantitative analysis was conducted on the effects of those alterations in parameters. The GCM is a vast model originally built on 19 intricately linked and embedded Microsoft Excel spreadsheets. With the current model, it takes about a day for the players and moderators to get through all the phases of the game, which are explained in detail in the following chapters. The game was built as a two-player (or two-group) board game, with a simple Graphical User Interface (GUI), which projects maps and spreadsheet displays onto a screen in order that players can get a bigger picture of the game set-up. The players would spend the morning analyzing the data and deciding which actions to take in order to meet their objectives. Once the players decided on a way forward the information was passed to the moderators who, according to the developers, would utilize the nineteen spreadsheets to analyze the results. This analysis could take from one to two hours, depending on the number of actions the players selected. The moderators would then return the results to the players, who would decide whether to proceed with selected actions or cancel and select new ones. The entire process was very human-intensive, and players could end up taking several hours waiting for the moderators to come up with all the calculations and conclusions for one to two rounds of actions selected by the players. Validating this model would be nearly impossible simply due to the time required to produce results based on spreadsheets.

To speed up the process we build a simulation model that utilizes random numbers to select all of the options that are normally chosen by the players. The spreadsheets and the embedded equations were analyzed, dissected and written into 30,000 lines of Java code. The resulting model required no human input, and could run 1,000 simulations of a single action and provide output results in less than 30 seconds. In this thesis all of the random operations of the model (of which there are dozens) are all specified by random numbers generated from user-selected distributions. In this way we allow the model to be vastly more general, and useful for much more than simple two-group play.

Although the object of the game is to provide training and analysis to the users, the object of the model is to analyze the options and show the validity of the game. Through this model we can understand the relationships of the input parameters and variables and the effects of changing these parameters. Additionally, utilizing the output of the model the effectiveness of the underlying mathematical algorithms can be examined. This verification allows the developers to obtain insight on the possible range of inputs and the acceptable corresponding outputs. The model could assist game players in testing different combinations of actions quickly and efficiently. The focus of this study was to analyze the output of a single action, in order to provide some validation that the game's performance and subject matter expert data. The Subject Matter Experts (SME) data (used as input parameters) was obtained from historical events, trends or conditions identified in the data obtained from the Afrobarometer website (http://www.afrobarometer.org/) surveys of the Nigerian people, is accurately reflected by the game. However, we have provided a general framework under which hypotheses can be evaluated and the effects of actions assessed. Throughout the process we were able to determine possible capability gaps, shortfalls and redundancies of the model and provide feedback to the developers.

To recap, in this thesis we provide a simulation-based front-end to the GCM that allows developers to simulate thousands of plays of the game, under general conditions determined by distributions of random numbers that are entirely under the control of the user. This should allow players, developers, analysts and policy makers the ability to assess and quantify the possible effects of choices (and the probability distributions of outcomes associated with those choices) in a way that has not been possible before now.

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II. GREEN COUNTRY MODEL BACKGROUND

A. BACKGROUND

The GCM is a competitive wargame that simulates the effects of soft factors in a social environment. Soft factors are the social interactions and interrelations of a local society and include such things as the population's beliefs, attitudes, disposition and ambience. The GCM attempts to incorporate the social entities of soft factors into an analytic game in order to explore shifting social empathy and interactions in close geographic regions and their associated constituents.

Currently in its third version, with a request pending for funding for further development, the GCM utilizes Diplomatic, Intelligence/Information, Military and Economic parameters to explore the Political, Military, Economic Social, Infrastructure, and Information rubric, which is explained in more detail below. The model was originally assembled to represent the country of Nigeria in a closed-form representation of the behavior and interactions of the population. It has since expanded to "games" representing regions of Central America (requested by U.S. NORTHERN COMMAND). Nigeria is the most populous country in Africa and is a major exporter of oil to the United States, as well as an emerging economic and commodity market for China and other international powers. Nigeria was chosen based on its strategic importance as well as its complexity, a complexity that includes internal conflicts, active insurgency in the southern region of the country, and ethnic and religious tensions that affect national politics, all of which make an interesting sociocultural model (Bos et al., 2011, p. 2).

B. SPECIFICATIONS AND CAPABILITES OF GCM

The GCM addresses a comprehensive environment where players engage in combat that involves social situations and tactics against opposing individuals, units or regions, selecting the best tactics and strategic procedures to accomplish a predetermined mission or goal. The game players (collectively called actors) are represented in three ways; the red player (the enemy or opponent), the blue player (usually the U.S, or "good guy") and Non-Player Actors (NPA). The actors can be represented on many different levels: national, international or local; and they can be a single person or group. The object of the game is for the blue player to try to accomplish an assigned objective through game play, while a red player opposes him or her in the quest and NPAs assist or deter the blue player's chosen actions. Players can be simply rivals or can be unequivocally opposed to each other. Additionally, they can chose to be strategic partners in order to accomplish objectives on both sides. Players work as a team, and may or may not choose to become allies or even cooperate with opposing players. The focus of the team lies in the agreement of accomplishing assigned goals. This aspect of game play brings in the human dynamics of real-life experiences, tactics and strategy of the individual players, as well as teamwork.

NPAs are entities not represented by actual players and are controlled by the game's "artificial intelligence" (underlying algorithms). These players can be such things as ethnic tribes, political parties, state and local governments, Non-Government Organizations (NGOs), religious groups or criminal organizations. NPAs are an important aspect of the game and are part of the moderator's response to a player's gaming. Interaction with a single NPA, or group of NPAs, is in response to an action or response selected by the players as progress is made through the game scenario towards an objective. NPAs can represent any individual or groups based on the theme of the gaming scenario. The actions and responses of the NPAs are programmed into the scenario using real-life examples and have been pre-determined by the Johns Hopkins SME: they are used in working with and coordinating operations with allies, ethnic groups, etc. Individual players, or teams, may or may not be skilled at a sufficiently high level of competence to accomplish a given task or goal, so interactions with the NPAs can be essential for success to be achieved; players can also be forced into a cooperative alliance.

Red and blue players play the game through the process of taking actions from a pre-determined list of realistic options for this region of play, a list that was established by the SMEs. The entire list of actions is made available to the players at the outset of the game. Players' choices are limited by the amount of resources available to them and in some cases may be constrained by other game conditions, which are discussed later.

Many game actions impact not only the players taking the action, but also the regions, and the NPAs associated with an action as well as the NPAs associated with a region. The game has no predefined victory conditions; players are assigned a strategic or specific goal, which is appropriate to the player, and the level at which the players have chosen to play at (e.g., United States government, terrorist group, leadership of Exxon Mobil, local vigilante group, etc.) An objective can be chosen by the player in attempt to plan and research possible alternatives, or can be assigned by the moderators of the game. The game ends either after a predetermined number of turns have elapsed or when a player meets his or her objectives. In this thesis, the objective, which are based on real-life events, is assigned by the moderator. The model results are compared to the results of the real-life events to determine the degree of accuracy that the model can reflect. The game moderator sets gaming objectives for the player or team of players. Such objectives can be concise and exact, giving the player exact goals needed to complete the scenario, or they might be to develop or expand strategic or operational doctrine already established in today's military organizations. To be able to meet such a widely varying objective list, the gaming platform needs to be developed as an adaptive modeled game, highly responsive to human decision-making processes that result in frequent changing of options and situations.

C. GAME PLAY SET-UP

Johns Hopkins University, Applied Physics Lab developed the GCM to incorporate and adapt to "human in the loop" game play. This type of game play is extremely dynamic and needs to accommodate human decision-making processes, which are difficult to predict or emulate. In order to incorporate human dynamics the developers introduced "interagency operations and collaborations" into the game play. As Simpkins et al. (2010) say, "[t]he GCM is a high-level, stochastic, multisided competitive influence game. It is especially useful at modeling interagency operations because the majority of its attention is given to soft power such as diplomacy, intelligence, information operations, civil affairs and economics." A key element of interagency operations is the players' interactions with the NPAs. Directed by the game's artificial intelligence, the NPAs may or may not cooperate with a player, and this decision of the NPA to cooperate or not is based on the relationship (affinity) with the player as well as the NPAs perceived self-interest (Simpkins et al., 2010, p. 3). By utilizing interagency collaboration, the model is attempting to follow the theory that the whole of combined actions is greater than the sum of individual actions. The decision to use collaboration in the model was based on the vastly complicated task of trying to predict the impacts of responsive actions, as some result in immediate consequences and others have consequences that are not realized for years (Simpkins et al., 2010, p. 1). The game play is broken into several phases. The information for these phases was obtained from a collaboration of references: Simpkins et al. (2010), Schloman et al. (2010) and Bos et al. (2011). The phases are further broken down into the activities and status of the players, moderators and the model activities. Each of the next five subsections previews the phases of the game and describes the activities of the players, the moderators and the model that take place in that phase.

1. Status Review Phase

Players: The moderator provides the players the value of their affinities, and resources, which includes the amount of Diplomacy, Intelligence, Military, and Economic points they are entitled to, as well as the value of their characteristics which are represented in the forms of hubris and influence points. Additionally, players are able to view the game map, which is divided into regions, as well as the Political, Military, Economic, Intelligence and infrastructure (PMESII) values allocated to each region. Blue players and red players are separated and conduct their game plays separately.

Moderators: Monitor player activities.

Model: No action.

2. Action Selection and Negotiation (Planning) Phase

Players: Select actions from the action table, based on the amount of resources they have available to them. Players cannot select actions, which they do not have enough resources to cover. Players may request permission or request a proxy action from NPA's during this phase of the game.

Moderators: Monitor player activities.

Model: No action.

3. Adjustment Phase

Players: No action.

Moderators: Obtain results of permission and proxy request responses calculated by the model, and relay results to players by altering one or all of the requesting player's resources, affinity, hubris, the region PMESII, or NPA's resources, affinity or hubris.

Model: Calculate non-player actor responses to the permission or proxy requests by players.

4. Action Results (Reallocation) Phase

Players: Upon receiving the results of the permission or proxy request, players finalize, alter or even cancel their actions and the turns are executed. If the players decide to cancel the action they can build a new action with their remaining resources; however they may not request another proxy or permission at this stage in the game.

Moderators: Monitor player activities, possibly choosing to inject new actions for NPA for the scenario if appropriate.

Model: No action.

5. Adjudication Phase

Players: No action.

Moderator: Evaluate the results of the model following submission of the player actions. Modify the game state data as appropriate.

Model: Executes the final actions, computes the results and applies them to player resources, regional status and affinity. Additionally executes various supporting algorithms for determining and updating trade, player-to-player affinity, regional PMESII scores, etc.

6. 1. Game Components

The next six subsections are a list of components that make up the game and are the pre-determined aspects that are given to players at the beginning of the status review phase.

a. Actions

The players are provided a list of actions, pre-established by a SME. These actions are selected by the player on their turn and submitted in the action selection phase of the game. Each action is associated with a "cost" which is represented in points allotted to four categories: Diplomatic, Intelligence, Military, and Economic (DIME). These four categories represent the power that the player has to select and make an action. If the player does not have enough points to cover the cost of an action then that action cannot be selected. The success or failure is determined by the roll of three six-sided dice, and the addition and subtraction of roll modifiers. The modifiers are based on four factors; the first three are affinity, hubris and influence scores of the player, the NPA, and the ethnic groups associated with each region. The PMESII scores of the region where the player has decided to take action determine the last modifier. Affinity, hubris, influence, PMESII, and DIME are described in more detail below.

b. Affinity, Hubris and Influence

Affinity is a value that represents the level of friendship between any two actors, player to player or player to NPA. Affinity influences the relationship(s) of the actor's characteristics and how they interact and relate to other actors in the region where the player has decided to take action. Affinity can be manifested as either Positive or Negative. Positive affinity promotes positive interactions with the NPA, which in turn results in an action being more likely to be successful and aids in progressing toward the scenario goals. Negative Affinity will require the player, or team, to provide incentives and negotiations that could lead to the NPA cooperating to attain the scenario goals. Negative Affinity can also play out in a hostile or negative reaction by the NPAs.

Hubris represents the pride, arrogance and haughtiness of a player (all actors have hubris). In this game hubris is a direct reflection of the resentment generated by a player for conducting unilateral, forceful actions on his or her turn. Hubris points accumulate through each turn, and can reduce or improve the likelihood of cooperation from NPA players.

Influence represents the players' status in the game, and is a reflected by respect or fear of the player by the other players. High influence scores will result in more cooperation from the other players and reduces the possibility of negative actions taken against the player.

c. Ethnic Groups

Ethnic groups play the role of NPAs; they impact the results of a play with their affinity, influence and hubris scores. When a player shares a strong positive affinity with an NPA, the player will be able to utilize the NPA's influence and hubris values to their advantage to complete an action. In contrast, a negative infinity will have a negative impact on the player's results. This is especially important when players are requesting permission or proxies on their turns. There are two types of NPAs associated with each ethnic group. The first is the ethnic group as a whole that occupies a region. Each ethnic group in the game is assigned an affinity score in the each region as well as an affinity score with the blue and red players and all other NPAs. The second type of NPA associated with the ethnic group is the "kingpin" NPA in each region. This is the NPA ethnic group that has the most impact in that region and is based on the affinity scores. The NPA with the highest affinity of any ethnic group in a region is essentially the "kingpin" of the region.

d. Regions

A map of the area of game play is divided up by into zones determined by the subject matter experts (SME) and then assigned PMESII values based on the real-world situation of each region. The size and composition of a region is dependent on the over-arching desires of the customer. However, once a particular game map is divided up into regions, the regions remain the same for every scenario. The PMESII values change after each turn of either the blue player or the red player and reflect the success or failure of an action as appropriate. However, the values are reset to the original values established by the SME, each time a new scenario is started. The ideal size for this game is 5–10 regions, and they can cover a city, a province or a country as in the case of Nigeria in this study.

e. Game Map

The Game Map provides the players with a visual reference to the game's objective and represents the gaming area divided into appropriate detail to meet the scenario parameters. Areas can be as small as a city block or as large as national borders in the wargame arena. Gaming parameters are set so that each geographic area or region will have set values based on a variety of elements: Politics (P), Military (M) prowess, Economic (E) and Social (S) status, Information (I) accessibility, and Infrastructure (I) of the target and surrounding areas. There may be some "spillover" effects from neighboring regions that slightly impact the values in a region, but generally the PMESII values in the regions remain constant, unless changed as a result of a turn. These elements will drive NPA actions during game in response to player actions and whether or not the NPA believes the action will result in self-benefit.

f. Facilities

Facilities (permanent structures such as military bases, embassies etc.) are indicators of a player's substantial long-term presence in a region. Facilities carry with them resource bonuses, indicating a player's increased capability to operate because of his presence in the region. Facilities may also provide increased likelihood of success for actions of the same resource type as the facility.

Facilities are aligned with the instruments of power they represent.

A Diplomatic (D) facility represents an embassy. It provides three Diplomatic resource points per turn to the owning player as well as an increased chance of success for Diplomatic actions taking place in that region.

An Intelligence (I) facility represents a CIA station or other intelligence center. It provides three intelligence resource points per turn and gives a bonus for intelligence activities in the region. Intelligence facilities may be covert.

A small Military (M) facility may be a training camp or special operations outpost. It may be covert. Small military facilities provide an additional three points per turn. A large military facility represents a large military base. It provides ten military resource points per turn.

An Economic (E) facility represents a factory or other production complex. It provides three additional economic points to the owning player per turn and improves the likelihood of success for any economic action undertaken in the region.

Facilities may be overt or covert. Covert facilities provide the owning player resource bonuses and applicable die roll modifiers but are not shown on the map unless discovered. An opponent's facilities may be discovered through Intelligence actions.

Facilities may be attacked. Successful attacks remove the facility from the map and end all bonuses they provide the owning player. Facilities are protected by the local military; the player may also assign additional security.

The owning player may voluntarily remove any facility at no cost. Removed facilities will no longer provide resources or die roll bonuses.

D. CRITICAL PARAMETERS AND SETTINGS

Note: The below values and explanations are taken from the Johns Hopkins White Paper, written by the developers of the game S.D. Simpkins, and Alex Ihde. This white paper is an unpublished informal game manual for the GCM. The parameters in this section are critical to understand as these values are what are analyzed during the verification and validation process. (White Paper, Simpkins & Ihde, 2010)

1. Conversions

Numerous parameters are scored on a value that ranges from less than -100 to greater than 100 within the underlying algorithms of the game's artificial intelligence.

However, these values are converted to numbers ranging from negative three to three, in order to make the game play less complex for players. Table 1 is a general scale that applies to the PMESII values in a region.

Table 1. PMESII Conversion Values

Reported Score	Characteristic Score	Comments
– 3	< – 100	Completely ineffective
– 2	– 41 to – 99	Mostly ineffective
– 1	– 10 to – 40	Poor
0	– 9 to 10	Neutral
1	10 to 40	Moderate
2	41 to 99	Effective
3	> 100	Outstanding

2. Political, Military, Economic, Social, Information, Infrastructure (PMESII)

a. Political (P)

This parameter reflects the effectiveness of the government. Political effectiveness impacts the flow of information, defense forces, law enforcement and the overall economy of a region. A low reported score (–3) indicates absolute corruption and ineffectiveness on the part of the government. A high score (3) indicates an honest government that facilitates progress of local programs and businesses.

b. Military – Regional (M)

This parameter represents the region's militia and law enforcement effectiveness. Of note, local M values may be increased through training. This value is driven by the readiness and capability of the local law enforcement, or national military. Generally it does not carry over from region to region but there may be a small amount of spillover from neighboring regions along the borders. A low reported score (–3) indicates a completely ineffective militia and law enforcement, which cannot defend itself or control violence. A high score (3) indicates a high military readiness, and the region's law enforcement and military components can defend and prevent terrorists and violence in that area.

c. Economic (E)

This parameter reflects the per capita income of the region. Low economic scores indicate a region in trouble and unable to sustain its population. High scores indicate a prosperous region.

d. Social (S)

This parameter reflects the contentedness of the population in the region. A low score indicates social unrest, whereas a high score indicates a content and peaceful population.

e. Information (I)

This parameter reflects the media penetration of the region, and indicates the ability for information to reach members of the society directly and quickly. Also under this category is literacy of the population, and the prevalence of wireless communication devices, television, radio and Internet. Regions with high scores are more susceptible to Information Operation campaigns.

f. Infrastructure (I)

This parameter reflects the state of the of the physical infrastructure of the region, including roads, rails, bridges, port cargo handling, air services, electricity and potable water. Poor infrastructure slows growth and economic progress.

3. Diplomacy, Intelligence, Military, Economic (DIME)

Points (or "resource points") are given to each player in the form of the DIME rubric: Diplomacy, Intelligence and Information, Military and Economic (finance). All actors possess resources expressed in the form of points that enable them to pursue their goals, in the case of the blue and red players, and in the case of the NPAs to perform within game parameters. As the actors progress through a turn, they may only select actions for which they have sufficient resources to cover: A player cannot exceed the level of effort set by the points. Unless impacted by an action, the player's resources are reset at the beginning of each turn, and remain constant until the end of the game. Once an action results in a decrease or increase of a player's DIME scores that new value becomes the new level of effort available to the player until the end of the game. Resource points affect the players' and NPAs' abilities to perform actions that will advance them toward the desired game objectives. Affinity, hubris and influence run in conjunction with players' DIME resources, often progressing in parallel.

a. Diplomacy

This parameter represents the personal interactions among actors. Diplomacy is used to communicate with other players and helps to increase or decrease affinity. Diplomacy points are used to take Diplomatic actions, and are helpful when requesting permission to act in a region controlled by an NPA, or to request an NPA to conduct an action on behalf of a player, known as a proxy in this game.

b. Intelligence

This parameter represents the attempt to gain or disseminate strategic information. Intelligence points cover two kinds of action: intelligence gathering and information operations. Intelligence gathering may provide the player with game information not otherwise available. For example, HUMINT (human-sourced intelligence) may provide the player with information regarding an NPA's affinity level with other NPAs in the game, the level of resources available to each NPA and actions the NPA plans to take. Information Operations (IO) are attempts by the player to change affinity or influence values in the game. IO may be used to either raise or lower the affinity value between two actors or to raise or lower an actor's influence value.

c. Military (Players)

This parameter represents the military resources available to a player. Military and law enforcement forces are usually focused on actions involving force. Military points represent the commitment of military units or other resources such as a logistics capability or missiles fired from offshore. Military units may attack, conduct peacekeeping missions, conduct training and do other things normally performed by military units.

d. Economic

This parameter represents economic resources and consists of economic and financial efforts.

4. Action Outcomes

Action outcomes are determined through a roll of three six-sided dice, yielding totals from three to eighteen. These numbers are modified based on influencing factors as identified on the action table. Results vary based on the adjusted value of the dice. Generally, higher numbers yield results more favorable to the player than low numbers. A 'natural three' always yields a poor result, while a 'natural eighteen' always produces a favorable result. Any other result is modified by influencing factors, with the adjusted number indicating the outcome for an action that a player selects from the actions table.

a. Influencers

(1) **Region.** Conditions in a region are expressed as PMESII scores, High (3 or 2) and low (–3 or –2) PMESII scores influence the outcome of an

action by modifying the value of the dice roll that determines the success of an action. Regional influences capture the limitations of poor infrastructure, and may impose penalties on an otherwise profitable economic program.

(2) **Player.** A player's hubris and influence characteristics can also influence the outcome of selected actions. Additionally, a player's strength in terms of one or more resources may influence the die roll value.

(3) **Target.** The target actor's characteristics are also important to the outcome of an action. Besides hubris, influence, and affinity, the target's capabilities (DIME values) can affect the action outcomes. For example a target with a powerful military is less likely to succumb to force than a target without military capabilities.

(4) **Total.** All influencing values are summed and the result is applied to the die roll. This modified result determines the outcome of the action.

b. Effects

After applying modifications to the action die roll, an effect is generated. The effect may impact the actor, the target and the region in which the action took place.

(1) **Actor**. The actor may be a player or an NPA that undertook the action at the player's request via a proxy. Actor effects include adjustments to hubris, influence and affinity (both actor-target and actor-region) scores, as well as possible consequences to the actor's DIME resources.

(2) **Region.** Certain actions may produce consequences to the region in which they are undertaken. Warfare may destroy the infrastructure, the economy or even the social fabric of the region. Aid given to starving people may increase consumer confidence and quiet unrest. Effects may linger beyond the turn on which they are imposed.

(3) **Target.** Some actions can produce consequences to their intended target. This may be true of benevolent actions such as economic aid or disaster relief, or of harmful actions such as military strikes or negative propaganda campaigns.

c. Victory

The game ends when the player has met the goals set by the game moderator or when the player or players, have completed the predetermined number of turns. In the event the game is ended due to a predetermined number of turns, whereby the player's progress toward objectives will be evaluated to determine success or failure.

E. UNDERLYING GAME MECHANICS

Note: The following ten pages are the underlying mathematical models of the GCM taken directly from the paper written by the developers of the game, "The Application of National Power: A DIME-PMESII parametric game," by S.D. Simpkins, A.G. Ihde, and M.P. Haney (Simpkins et al., 2010.) This article explains each of the equations utilized in the underlying infrastructure of the game, which is what provides the artificial intelligence of the game. Additionally the paper provides an essential short verification (using MATLAB) of each of the equation in order to understand the behavior of the equation. This was an important study, which the developers used to ensure that the underlying algorithms were performing as expected.

There are six mathematical algorithms used in the model, which rely on a common set of indices:

- Let $i, j \in R$, the set of Regions $\{R_1,\ldots,R_k\}$ where k is the maximum number of regions in the game, and i, j are the regions targeted by the action.
- Let $m, n \in S$, the set of Regional attributes {PMESII} where p. represents the last regional attribute.
- Let $t \in T$, game turns $\{1, \ldots, T_I\}$ planned, where I is the planned number of game turns
- Let $x, y \in A$, the set of Actions $\{A_1,\ldots,A_z\}$ where z is the number of possible actions
- Let $a, b, c \in P$, the set of Actors $\{P_1, \ldots, P_d\}$ where d is the number of actors in the game, a is the actor, b is the target, and c is the requesting player.
- Let $f, g \in F$, the set of Facilities $\{F_1 - F_h\}$ where h is the number of facility types in the game, and f and g represent the facilities in the region.

- Let $q, r \in C$, the set of Characteristics and Resources {Hubris, Influence, DIME} where s is the last characteristic in the set.

1. Permissions/Proxy

A player has three choices when selecting an action. The first choice is to ask permission for the action from the regional leader (an NPA). The second choice is to ask another NPA to complete the action via proxy, and lastly the player can choose to take the action without asking permission or via proxy. This decision takes place in the Action Selection and Negotiation phase. Permission is granted based on a random number and the addition or subtraction of modifying factors. If the sum of the random number and the modifier is greater than the permission threshold, then the permission is granted, and the actor can proceed with the action, with permission from the regional leader without penalty. If permission is not granted and the player decides to continue with the action, then the player may receive a hubris penalty, which is added (the higher the hubris the more arrogant) to his or her hubris total following the execution of the play. The developers inserted the random number to add an element of chance to the game, to reflect the reality that international diplomacy may often produce unexpected results. Additionally, SMEs determined a set of weighting factors, which were bound to the model in order to improve game play and produce more realistic results. The following weights apply

- τ_1 = weight for benefit of hearer (regional leader)
- τ_2 = weight for target (player affected by the action) consequence
- τ_3 = weight of target fear
- τ_4 = weight of leader affinity to requesting player
- τ_5 = weight of leader fear of requesting player
- τ_6 = weight of hubris of requesting player

The following is provided for the below equation (which calculates the value which will be compared to the permission threshold):

a = the leader; b = target; c = requesting player where ($a, b, c \in P$)

Benefit$_a$, *Benefit*$_b$, *Benefit*$_c$ is the impact from the action on actor *a* or target *b*. This value is calculated based on the whether the benefit is for the regional leader, the target or the actor taking the action, *c*.

Affinity$_{a,b}$, *Affinity*$_{a,c}$ is the affinity between players *a* and *b* or players *a* and *c*

Influence$_a$, *Influence*$_b$ is the influence attributed to player *a* and *b* respectively.

Fear$_{a,b}$, *Fear*$_{a,c}$ is the amount of fear between the actors. It is based on the amount of influence that each actor possesses.

Self-Benefit represents the importance that the benefit to the leader carries compared to the benefit to other actors (corresponds to the affinity value)

2. Permission Equation:

$$Random\,\# + \left[\tau_1 * Benefit_a * SelfBenefit\right] + \left[\tau_2 * Benefit_b * Affinity_{a,b}\right] +$$
$$\left[\tau_3 * Benefit_b * fear_{a,b}\right] + \left[\tau_4 * Affinity_{a,c}\right] + \left[\tau_5 * fear_{a,c}\right] + \left[\tau_6 * Hubris_c\right] \geq Threshold$$

If the value is greater than the permission threshold (established by SME) then player *c* is granted permission to take requested action.

The components of Permission Equation are:

$[\tau_1 * Benefit_a * Self\ Benefit]$ which represents the impact on the leader. This is probably the most influential of the components, because if the action is beneficial to the leader then he or she is more likely to grant permission.

$[\tau_2 * Benefit_b * Affinity_{a,b}]$ which represents the impact on the target. This is a modifier that multiplies the potential benefit to the target by the affinity he or she shares with the target. In other words, an action that benefits the leader is likely to be approved then an action that will not benefit the leader.

$[\tau_3 * Benefit_b * Fear_{a,b}]$ which represents the leader's fear of the target. In this game if the target's influence score is greater than the leader's influence score by 10 points, then the leader will fear the target.

$[\tau_4 * Affinity_{a,c}]$ which represents the leader's affinity with the player requesting the permission or proxy. A greater affinity should result in a greater willingness to grant permission.

$[\tau_5 * Fear_{a,c}]$ which represents the leaders fear of requesting player.

$[\tau_6 * Hubris_c]$ which gives the requesting player's hubris.

The same equation is used for a request for a proxy action, except that in this case the leader applies a benefit value of one. Again, if the value of the expression is greater than the SME predetermined proxy threshold, then the request for proxy is granted.

3. Action Input Modifiers

When a player or team decide on an action, and it is submitted in the Action Results Phase, the results of the action in terms of varying degrees of success and failure are determined by the sum of three dice after the addition and subtraction of influence modifiers. When a player or team rolls either a three or an eighteen the action is taken as a complete failure or success respectively; influence modifiers are not applied to a roll of three or eighteen. However, all other values of the sum of the dice are modified by a series of factors which will be explained in this section.

4. Action Modifier Equation

Let the following relationships apply:

- d = regional leader of the region j for which the action is requested.
- *Covert Modifier (CM)* $= (CovertMod_x * Covert)$
    - $CovertMod_x$ is the modifier for covertness for action x.
    - *Covert* is 1 if action is covert, and 0 otherwise.
- *Scale Modifier (SM)* $= (ScaleMod_x * Scale)$
    - $ScaleMod_x$ is the modifier corresponding to the scale of action x.
    - *Scale* is the scale chosen for the action.
- *Actor Modifier (AM)* $= (\tau_7 \Sigma_{q=1-s} * ActorMod_{x,q} * ActorChar_{a,q})$
    - $ActorMod_{x,q}$ is the modifier associated with any action x relative to resource or characteristics q of player a.
    - $ActorChar_{a,q}$ is the characteristic q associated with any actor a (in this case a can fill the roll of the target, object, regional leader or actor)
    - τ_7 is the weight for actor modifiers.
- *Actor Facility Modifier (AFM)* $= (\tau_8 \Sigma_{f=1-h} * ActorFacMod_{x,f} * ActorFac_{a,f,j})$
    - $ActorFacMod_{x,f}$ is the modifier associated with the facility(f) for action x of the player.

- $ActorFac_{a,f,j}$ is 1 if the actor has a facility of type *f* in region *j,* 0 otherwise.
- τ_8 is the weight for actor facility modifiers.

- Target Modifier (TM) = ($\tau_9 \Sigma_{q=1-s}$* TargetMod$_{x,q}$ * ActorChar$_{b,q}$)
  - $TargetMod_{x,q}$ is the modifier associated with any action *x*, relative to resource or characteristic q.
  - $ActorChar_{b,q}$ is the characteristic q associated with any actor b (in this case b fills the roll of the target)
  - τ_9 is the weight for target modifiers
- *Target Fac Modifier(TFM)= + (*$\tau_{10}\Sigma_{f=1-h}*TargetFacMod_{x,f}*ActorFac_{b,f,j}$*)*
  - $TargetFacMod_{x,f}$ is the modifier associated with facility *f* for action *x*.
  - $ActorFac_{b,f,j}$ is 1 if the actor has a facility of type *f* in region *j,* 0 otherwise.
  - τ_{10} is the weight for target modifiers.
- *Object Modifier (OM) = (*$\tau_{11}\Sigma_{q=1-s} * ObjectMod_{x,q} * ActorChar_{c,q}$*)*
  - $ObjectMod_{x,q}$ is the modifier associated with any action *x* relative to resource or characteristic *q*
  - $ActorChar_{c,q}$ is the characteristic *q* associated with any actor *c* (in this case an object)
  - τ_{11} is the weight for object modifiers.
- *Object Fac Modifier (OFM) = (*$\tau_{12}\Sigma_{f=1-h}*ObjectFacMod_{x,f}* ActorFac_{c,f,j}$ *)*
  - $ObjectFacMod_{x,f}$ is the modifier associated with facility *f* for action x.
  - τ_{12} is the weight object facility modifiers.
- *Region Modifier (RM) = +(*$\tau_{13}\Sigma_{m=1-p} * RegionMod_{x,m} * RegionAttribute_{m,j}$ *)*
  - $RegionMod_{x,j}$ is the modifier associated with attribute *j* for action *x*.
  - $RegionAttribute_{j,m}$ is the attribute *j* associated with Region *m*.
  - τ_{13} is the weight for regional modifiers.
- *Econ Modifier (EM) = +(*$\tau_{14}[EconMod_{x,a,b}* Econ_{a,b} + EconMod_{x,b,a}* Econ_{b,a} + EconMod_{x,d,a}* Econ_{d,a}+ EconMod_{x,c,b}* Econ_{b,c}]$
  - $Econ_{a,b}$ is the level of trade from actor a to target *b*.

- $EconMod_{x,a,b}$ is the modifier associated with the trade level from actor *a* to actor *b* for action *x*.
- τ_{14} is the weight for econ modifiers.

$$Action\ Modifier = CM + SM + AM + AFM + TM + TFM + OM + OFM + RM + EM$$

5. Affinity Resolution

All players in the game have an affinity score with respect to every other player. The affinity represents the relationship between two actors and ultimately results in the amount of cooperation between two actors. A positive value will more than likely result in acceptance of a permission or proxy request or an action, and more cooperation between the two players. Negative affinity is an indication there may be hostility and or apathy between the two players, resulting in less cooperation between the two. NPA's will require more incentive to cooperate if the affinity with the requesting player is negative.

Affinity scores are tracked in the same method as players' characteristics and resources, players are given a score on a scale of -3 to 3 whereas scores internal to the game are tracked based on a value of -100 to 100, with zero as the neutral value. Table 2 describes the affinity between two actors:

Table 2. Affinity Conversion Values

Reported Score	Characteristic Score	Comments
–3	< –100	Near warfare or absolute hostility
–2	–41 to –99	Hatred. Strong resistance to requests
–1	–10 to –40	Mild dislike. Beneficial actions permitted
0	–9 to 10	Neutral
1	10 to 40	Positive. Increased cooperation
2	41 to 99	Friendship, most activities permitted
3	>100	Alliance. Harmony and partnership

Players with an affinity score of three with an NPA may employ the resources belonging to that respective NPA. All of this NPA's affinity values are revealed to the player.

There are two ways during game play in which affinity scores are changed, one as a direct result of a specific action taken by a player. Or the second "through an algorithm that assesses a player's relationships with all NPAs in the game, and determines the impact for the state of each relationship on all the others." So a player with a high affinity score with an NPA will more than likely result in increased cooperation between the two players.

Affinity Equation

$$aff_{a,b,t+1} = aff_{a,b,t} + adj_{a,b,t} + \sum_{\substack{\{x \text{ in actions}\} \\ \{j \text{ in regions}\} \\ \{c \text{ in players}\}}} acteff_{a,b,t,x,j,a,c} + \sum_{\substack{\{x \text{ in actions}\} \\ \{j \text{ in regions}\} \\ \{c \text{ in players}\}}} acteff_{a,b,t,x,j,b,c}$$

Here:

- *a, b, c* refer to actor, target, and hearer (a third-party, e.g., the region's kingpin)
- t names the turn
- x indexes the set of actions
- j indexes the set of regions
- c indexes
- $aff_{a,b,t}$ is the affinity between actors a and b from the previous turn t
- $adj_{a,b,t}$ is the adjustment resulting from "the enemy of my enemy" (see below)
- The third term is a triple sum across actions, regions, and across all players acted on by player a. Each interaction between a and another player has a potential effect ("acteff" for "action effect") on the affinity between a and b.
- The fourth term is a triple sum across actions, regions, and across all players acting on b. Each interaction between b and another player has a potential effect on the affinity between a and b.

- Adjustments are considered when there are strong feelings of affinity between any two of the parties (requestor, hearer, target) involved in an action. The variable $adj_{a,b,t}$ is the sum of two terms.

If the $aff_{requestor,hearer}$ is extreme and the $aff_{hearer,\,target}$ is extreme and in the same direction:

$$\text{term1} = \sum_{hearers} \frac{\left|aff_{hearer,\,target} + aff_{hearer,\,requestor}\right|}{10}$$

If the $aff_{requestor,hearer}$ is extreme and the $aff_{hearer,\,target}$ is extreme and is in the opposite direction:

$$\text{term2} = \sum_{hearers} \frac{\left|aff_{hearer,\,target} + aff_{hearer,\,requestor}\right|}{-10}$$

(Extreme values indicate $|\,aff\,| > 40$, which scales to > 2 or < -2 on Table 2)

Here the "requestor" can be either player a or a proxy; the "hearer" is the region's kingpin; and the "target" is player b.

6. Region PMESII Attributes

This equation is the algorithm which determines the PMESII values for the regions. Using the original PMESII value for each region, it adds a triple summation of all the results of the actions, across all regions, by each player in a turn (equation in first set of parenthesis) multiplied by a weighting factor. The second term in parenthesis is the internal portion of the equation that sums all of the PMESII effects on each other across all PMESII values, across all regions, multiplied by a weighting factor. The fourth term is the association portion of the equation, which sums the impact of regions on regions across all regions, and multiplies them by a weighting factor. The last terms are the random variate, which is incorporated into the equation.

$$\beta_{m,\,i,\,j+1} = \beta_{m,\,i,\,j} + \left(\tau_a * \sum_{\substack{\{x \text{ in } actions\} \\ \{i \text{ in } regions\} \\ \{a,\,b,\,c \text{ in } players\}}} \varepsilon_{x,\,a,\,i,\,b,\,c,\,t} * \left[actionEffects\right]_{x,\,a,\,i,\,b,\,c,\,t} \right) + \left(\tau_{in} \sum_{\{n \text{ in } PMESII \text{ state}\}} \tau_{mn} * \left(\beta_{m,\,i,\,j} - \beta_{m,\,i,\,j}\right) \right) + \left(\tau_{ra} \sum_{\{j \text{ in } regions\}} \tau_{ij} * \left(\beta_{n,\,i,\,j} - \beta_{m,\,i,\,j}\right) \right) + \tau_{rv} * v$$

$a, b, c \in P$ where $a,\ b,$ or c denotes actors
$i, j, c \in R$ where i or j denote specific geographic regions
$m, n \in S,$ where m or n denote which PMESII values will be used
$x, y \in A$ where x or y denote the specific actions taken by players, $a,\ b,\ c$
$\beta_{m,i,t} \in \mathbb{R}$ where $\beta_{m,i,t}$ denotes PMESII state m in region i at turn t (this is
an absolute value that ranges from $-100 \geq \beta_{m,i,t} \geq 100$
$\varepsilon_{x,a,i,b,c,t}$ denotes when an action is taken by a player, this is a binary value
set to 1 when an action is taken and multiplied by the result of the action
$\tau_a =$ action weight, applies significance weight of action a
$\tau_{in} =$ internal weight, applies a significance to PMESII interactions
$\tau_{mn} =$ internal impact weight applied to the affect β_m on β_n
$t_{ij} =$ regional impact weight applied to the affect of region i and region j
$\tau_{ra} =$ regional impact weight, applies a significance weight to regional association
$\tau_{rv} =$ random variable weight, applies a significance value to the random variable
v = random variable

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III. SCENARIO DESIGN AND GAME SET UP

A. INTRODUCTION

In order to create a simulation based model it was necessary to generate random numbers to select various roles in the game. In Java, a uniform random number generator (RNG) was utilized for this so that a turn could play through completion without human interaction or input. We generate random numbers to select each of the items listed in Table 3. This table shows the number of random variates required by this simulation for one turn of game play by one player. In every case we select from a set of choices (column 3) with equal probability (column 4) for this exercise (except that some Uniform (0,1) values are required for the PMESII changes), but users may select form any of the set of choices with any set of probabilities. We briefly examine the effect of changing some of these distributions in the Follow-On Simulations section of Chapter IV.

Table 3. Table of Random Numbers Generated

Random Number	Description	Number of Choices	Probability of choice
1	Type of Action (DIME)	4	25%
2	Actual Action: There are four types of actions; once the type of action is determined the actual action is selected. Under each type of action there is a variable number of actions. This RNG will select which action is to be played (e.g., the D type action has six different actions to select from so each action has an equal chance of selection with a probability of 16.67%) .	If D, 6 If I, 16 If M, 24 If E, 11	each D 16.6667 each I 6.25% each M 4.1667% each E 9.0909%
3–5	Three fair six sided dice: Used in conjunction with the modifiers to determine the results the action is selected.	If Die 1, 6 If Die 2, 6 If Die 3, 6	Each die side has a 16.6667% chance
6–8	Three fair six sided dice: Used in the calculation to determine whether the proxy or permission request will be accepted or declined.	If Die 1, 6 If Die 2, 6	Each die side has a 16.6667% chance

		If Die 3, 6	
9	Region of Action	8	12.5%
7	Target selection: If it is determined that the action only applies to an NPA, there are five NPA's to select from, each with and equal 20% chance of selection. If the action applies to only a region, then there are eight regions with an equal 12.5% chance of selection.	If NPA only, 5 If Region only, 8 If Both, 13	Each NPA 20% Each Region 12.5% If Both 7.69%
8	Proxy selection: Is based on the region selection, the proxy is randomly selected from one of three NPAs. The three choices are the GoN, and the two NPAs with the highest influence, if GoN is one of the two NPA's with the highest influence then the NPA with the third highest influence is selected.	3	Each 33.33%
9	Option modifier: On some actions the player has an option to spend resources on additional modifier points. All but three actions that have this option available have only one option on how many modifier points they can purchase. This RNG, determines whether the player will chose to take this option if it is available to this action.	2 (yes or no)	Each 50%
10	Extra Modifier: Three of the actions have a choice on how many points that can be purchased. This RNG will select the choice for these three actions	Action 3.22, 5 Action 4.9, 3 Action 4.11, 3	If 322, 20% If 49, 33.33% If 411, 33.33%
10	Permission, Proxy, Unilateral action: This RNG is used to select whether this action will be made after requesting permission, via a proxy or conducted unilaterally	3 choices	Each 33.33%
11–59	PMESII equation: The random number utilized in equation 5 which is used to calculate the PMESII changes in each region.	one number per region per PMESII value	Uniform (0, 1)

B. STATUS REVIEW PHASE

1. Initial Player Information

a. Blue and Red Player Resources:

These values are determined by the subject matter experts and are based on the amount of power a player should have. Note: Players can not see each other's values.

(1) Blue Resources

Influence	Hubris	D	I	M	E	Gen
20	15	12	15	55	20	30

(2) Blue Affinities

GoN	MEND	Thugs	IMN	Church	NW	NE	NC	FCA	Lagos	SW	SS	SE
–1	–3	3	1	–3	2	2	1	–1	–2	–2	–2	–2

(3) Red Resources

Influence	Hubris	D	I	M	E	Gen
12	16	2	10	5	0	4

(4) Red Affinities

GoN	MEND	Thugs	IMN	Church	NW	NE	NC	FCA	Lagos	SW	SS	SE
–1	–3	3	1	–3	2	2	1	–1	–2	–2	–2	–2

b. Game Map

The game map is divided into eight regions. Players select a region where the action is going to take place. For this study a new independent uniform random number is generated to select the region of play. All of the NPAs exist in each region; however, each NPA has a different affinity value in each region. Players can ask permission to conduct an action of either the GoN, or of the NPA with the highest affinity in the region. The organization with the higher affinity would be the best choice to ask, but either can be asked. A Proxy is requested from the two highest affinity NPAs or the GoN within each region.

Figure 1. Map of Nigeria broken into regions

- Region 1 – North West (NW) Zone

(1) The NPAs with the highest affinity in this region are the IMN with 55 affinity points and Thugs with 42; the GoN affinity is 11.

- Region 2 North East (NE) Zone

(2) The NPAs with the highest affinity in this region are the IMN with 110 affinity points and Thugs with 38; the GoN affinity is –4.

- Region3 North Central (NC) Zone

(3) The NPAs with the highest affinity in this region are the IMN with 65 affinity points and Thugs with 42; the GoN affinity is 55.

- Region 4 Federal Capital Territory (FCA)

(4) The NPAs with the highest affinity in this region are the IMN with a 20 affinity and GoN with affinity 68.

- Region 5 Lagos

(5) The NPAs with the highest affinity in this region is the church with an 80 affinity and GoN with affinity 90.

- Region 6 South West (SW) Zone

(6) The NPAs with the highest affinity in this region is the church with a 50 affinity and GoN with affinity 45.

- Region 7 South South (SS) Zone

(7) The NPAs with the highest affinity in this region is the church with a 44 affinity and GoN with affinity 31.

- Region 8 South East (SE) Zone

(8) The NPAs with the highest affinity in this region is the MEND with a 95 affinity, the church with a 91 affinity; the GoN affinity is 19.

c. Region PMESII Values

Values Determined by SME

Table 4. Region PMESII values

	Pol	Mil	Econ	Soc	Info	Info
Region 1	–35	–55	–5	15	–2	–65
Region 2	–70	–100	–75	–15	–60	–50
Region 3	0	–68	–1	1.7	–15	–20
Region 4	–5	65	20	65	32	45
Region 5	15	45	90	75	50	45
Region 6	–5	16	35	56	58	35
Region 7	–87	16	19	–105	65	15
Region 8	–50	–35	–40	–12	40	–35

Table 5. Player PMESII display values

	Pol	Mil	Econ	Soc	Info	Info
Region 1	–1	–2	0	1	0	–2
Region 2	–2	–3	–2	–1	–2	–2
Region 3	0	–2	0	0	–1	-1
Region 4	0	2	1	2	1	2
Region 5	1	2	2	2	2	2
Region 6	0	1	1	2	2	1
Region 7	–2	0	1	–3	2	1
Region 8	–2	–1	–1	–1	1	–1

d. Non Player Actors (NPA)

(1) Government of Nigeria (GoN): An NPA throughout the country of Nigeria; however it is located predominately in the FCA region. GoN is considered the "kingpin" in the FCA and Lagos regions.

(2) Islamic Movement in Nigeria (IMN): A minority Shiite group advocating Syncretism. Located in the NW, where they are the established "kingpins."

(3) Movement to Emancipate the Niger Delta (MEND): A group of Igbo and some Ijaw tribesmen wanting a bigger share of oil profits. Located in the SS zone and the SE, they are considered the "kingpins" of the SE.

(4) Church: An amalgamation of the Christian religious sects represented there, even though they support substantially different political parties. Predominately located in the South, they are also considered the "kingpins" in SW and SS.

(5) Thugs: (self-explanatory). Located predominantly in the North, they are not considered kingpins of any region but can be used for proxies.

C. ACTION SELECTION AND NEGOTIATION (PLANNING PHASE)

1. Select Actions

Players are provided the actions table with a brief description of each action as well as the cost. Players decide as a team what action they are going to select based on the objective of the game, which is provided by the moderator, or already established by the players in an attempt to study and provide training for a pre-determined situation and the possible impacts, of their actions. The actions table is custom-made by the SME and the players, and is established prior to the game commencing. The actions are based on current situations in the country as well as on input from the players on what they would like to see in the game. In this study, each action is either selected by the moderator if a particular test is to be run, or by two random numbers, one to select the type of action (DIME) and the other to select the actual action based on the DIME selected previously. It is important to note that all random numbers are generated from one single random number generator in Java, so that the experiment could be replicated, when a seed value is utilized. The two random numbers allows percentage distributions to be put on the type of action (e.g., 50% of actions will be Intel). Table 6 is the action table provided to players for action selection. The action selected is based and the goal of the game established prior to game commencement, and is determined by the moderator or the players who may want to explore the possible results of an action in a training and planning evolution. The cost of the action is the amount of resources the player must have in order to be allowed to select that action. If the player does not have enough resources to cover the cost of the action that action can not be selected. In this study the action is selected by a random number generator. If the player does not have enough resources to cover the cost, the play will end, and the next turn will commence, resetting the values of the player resources to original settings.

Table 6. Actions List

DIPLOMATIC ACTION	Description	COST D	I	M	E
Diplomatic overture / visit (small)	Visit by minor diplomat / major diplomat / team of envoys (action 11)	1			
Covert Diplomatic visit (small)	Secret Visit by minor diplomat / major diplomat / team of envoys (action 12)	2			
Diplomatic overture / visit (med)	Visit by team of envoys (action 13)	3			
Covert Diplomatic visit (med)	Secret Visit by team of envoys (action 14)	6			
Diplomatic overture / visit (large)	Visit by minor diplomat / major diplomat / team of envoys (action 15)	10			
Long-term Diplomatic Presence	Establish consulate/"Build Embassy" (uses 7 points for 3 consecutive turns) (action 16)	7x3			
INTELLIGENCE / INFORMATION ACTION					
Conduct Intelligence Efforts					
Conduct HUMINT, investigation (small)	Intelligence personnel attempt to gain understanding of group . This action is automatically covert (action 21)		1		
Conduct HUMINT, investigation (med)	Intelligence personnel attempt to gain understanding of group . This action is automatically covert (action 22)		3		
Conduct covert investigation (med)	(action 23)		6		
Conduct HUMINT, investigation (large)	Permissive: Large requires 2 affinity. Medium requires 1 affinity. (action 24)		10		
Conduct covert investigation (large)	Permissive: Large requires 2 affinity. Medium requires 1 affinity. (action 25)		20		
Penetrate NPA group	Intel personnel penetrate the organization. * - if caught. Otherwise, penalties do not apply. (action 26)		3		
Conduct Information Operation	Action (27 placeholder in game, not used)				

Small ‘target positive’ campaign	Usually done to improve player image in an area where it’s low May be done to support an ally (action 28)		5		
Large ‘target positive’ campaign	Usually done to improve player image in an area where it’s low May be done to support an ally (action 29)		15		
Small ‘target negative’ campaign	Releases of negative news stories, commercials, ads. Operation is assumed covert at this cost. (action 210)		5		
Large ‘target negative’ campaign	Releases of negative news stories, commercials, ads. Operation is assumed covert at this cost. (action 211)		15		
Small ‘target effective’ campaign	Reinforces perception that targeted group is powerful (action 212)		5		
Large ‘target effective’ campaign	Reinforces perception that targeted group is powerful (action 213)		15		
Small ‘target ineffective’ campaign	Reinforces perception that targeted group is weak (action 214)		5		
Large ‘target ineffective’ campaign	Reinforces perception that targeted group is weak (action 215)		15		
“Build CIA Station”	Inserts a token on the board. Automatically covert (uses 7 points for 3 consecutive turns) (action 216)		7x3		10
MILITARY ACTION					
Small security operations:	Conduct a small security operation (action 31)			3	
Covert small security Operation	Conduct a small covert security operation (action 32)			6	
Medium security Operation	Conduct a medium security operation (action 33)			10	
Covert Medium security Operation	Conduct a medium covert security operation (action 34)			20	
Large security Operation	Conduct a large security operation (action 35)			30	
Small Peacekeeping / Peacemaking	Establish small military presence to prevent violence (action 36)			10	
Med Peacekeeping / Peacemaking	Establish med military presence to prevent violence (action 37)			30	
Large Peacekeeping / Peacemaking	Large military presence to preserve order, prevent violence (action 38)			80	
XS Combat Operations	Very small: car bombing, foot-mobile bomber. Sniper. Sm raid. (action 39)			3	

S Combat Operations	Small: truck bombing, platoon sized attack. Direct engagement of a small target (building). (action 310)			10	
M Combat Operations	Medium: Raid, company sized attack. Direct engagement of a larger facility. (action 311)			20	
L Combat Operations	Large attack (Bn-sized). Direct engagement on large facility, compound. (action 312)			40	
VL Combat Operations	Very large operation/invasion (BDE sized). (action 313)			80	
Covert Operation - XS	Small squad sized covert attack (action 314)		3	10	
Covert Operation - S	Larger covert raid (action 315)		6	20	
Humanitarian Assist / Disaster Rel - S	Small effort to provide emergency aid (action 316)	3	1	10	5
Humanitarian Assist / Disaster Rel-M	Larger effort to provide emergency humanitarian relief. (action 317)	7	2	20	10
Humanitarian Assist / Disaster Rel-L	Very Large effort to provide emergency humanitarian relief. (action 318)	15	5	40	20
Training / Exercise - S	Small training exercise (action 319)			10	
Training / Exercise - M	Medium training exercise (action 320)			20	
Training / Exercise - L	Large training exercise (action 321)			40	
Personnel taking - arrest / kidnapping	Kidnap or have target arrested (uses 1 points first turn, 3 points second turn and 10 points third turn) (action 322)			1x3x10	
"Build Base"	Inserts a token on the board (uses 7 points for 3 consecutive turns) (action 323)	5		7x3	10
"Build Covert Training Camp"	Inserts a token on the board (action 324)			5	5
ECONOMIC ACTION					
Business Program / Initiative - Small	Expand business contacts. Make small investments, Support existing infrastructures (action 41)	1			10
Business Program / Initiative - Med	Conduct business with existing companies (action 42)	2	1		20

Business Program / Initiative - Large	Build Personal Business Infrastructures (action 43)	3	2		40
"Build Factory"	Inserts a token on the board. (action 44)	5	3		7x3
Provide Stimulus Aid - Large	Give money to organizations. (action 45)				20
Provide Stimulus Aid- Small	Give money to organizations. (action 46)				7
NGO Support	Fund NGO humanitarian activity in a region (action 47)				10
Impose Sanctions	Restrict the power of an economy (costs 4 every turn) (action 48)				4
Lift Sanctions	Increase economic involvement, Must have sanctions in place (action 49)	0	0	0	0
Raise Tariffs	Increase tax on imports and exports (action 410)	0	0	0	0
Lower Tariffs	Decrease tax on imports and exports, Must have tariffs in place (action 411)				4

2. Selecting NPAs

During this phase the players decide on the target for which they desire to perform the selected action. In this simulation the type of action and a random number determines the target. For each action it was determined if the action could take place on an NPA only, a region only, or if it could take place on both an NPA and a region. Once this is decided, a random number is generated, to select the target for the action based on the type of target available for that action. By classifying what type of target and action could be performed, the chance of an infeasible action was reduced (e.g., the action "kidnap NPA" occurs on an NPA, not a region; "build a CIA station" occurs in a region, not an NPA). The players also decide if they are going to ask for permission or proxy during this phase or act unilaterally. In this simulation a random number was selected to determine if the player was going to ask permission, ask for a proxy or act unilaterally. The action, target and desire to ask permission, proxy or unilaterally along with the hearer (who is being asked for permission or proxy) is passed to the game's artificial Intelligence and the moderator to determine the results of the request for permission or proxy.

D. ADJUSTMENT PHASE

During this phase the players have no actions; the game's artificial intelligence determines whether the proxy is accepted or permission granted if either has been requested. The approval of either a proxy or permission is determined by the proxy or permission equation cited in chapter two. If permission was granted or proxy accepted, then the player experiences an increase of 10% of the starting affinity with the region and the hearer NPA, as the two entities develop a better relationship. If permission was denied or proxy declined then there is a 10% decrease in the affinity between the player and the region and the player and the hearer NPA. In this simulation only the two NPAs with the highest affinity score, and the GoN (even if it is not the NPA with the highest affinity) can be asked permission or proxy.

E. ACTION (RESULTS REALLOCATION) PHASE

During this phase, players decide whether to submit their action to the moderator or to cancel the action. This is based on the results of the permission or proxy request, which is determined in the adjustment phase. In this study, the goal is to study the effects of the various actions; therefore the players are not allowed to cancel an action. Instead the player will continued the action, but experience an increase of hubris, for continuing the action despite being told no.

F. ADJUDICATION PHASE

During this phase the game's artificial intelligence utilizes the underlying algorithms to provide the results of the action. The underlying algorithm, which is cited in chapter two as the Action Modifier Equation is based on a roll of three, six sided fair dice (three random numbers drawn) and the addition or subtraction of all the roll modifiers. Roll modifiers are different for each action and are based on the PMESII values of the region selected, the hubris and influence of the player, the affinity of the player and the target, whether the action is covert or overt and whether there are any facilities owned by the player, and whether or not the player options to buy modifiers using resources.

Success of the action is determined by the value of the dice roll and the addition or subtraction of the modifiers from the dice roll. Each action has a results key similar to that of Table 7. However, the actual values and results are determined by SME, who have studied the trends of the country utilizing the Afrobarometer data. This study takes the values and results provided by the SME at face value and does not analyze the correctness of the SME decisions.

Table 7. General Action Results

3	Complete failure
<5	Medium Failure
5–7	Small Failure
8–12	No effect
13–16	Small success
17+	Medium success
18	Complete success

Once the results of the action have been determined, the following resources, affinities and characteristics are changed: Player-region affinity, player-target affinity, player-hearer affinity, player-region affinity, target-hearer affinity, region-target affinity, hearer-region affinity, player hubris, DIME, influence, target hubris, hearer, influence, region PMESII, NPA benefit and self-benefit values. Once values have been calculated, a new turn starts or the game is over, depending on the initial criteria established prior to the game commencing.

IV. ANALYSIS AND DESIGN OF EXPERIMENTS

A. PARAMETERS AND VARIABLES

This game was originally developed to study the results of an action on society and to help players understand the possible repercussions for a particular action. The factors to consider are the PMESII values of the regions and how they are affected after a player's turn, as well as the affinity values among players and regions. This model consists of roughly 2,000 input parameters, which were incorporated into the "games" underlying algorithms listed in chapter two. The developers provided the spreadsheets that were used to play the game for this study, and the model was recreated in Java using the exact equations provided in the spreadsheets, in order to reduce interpretation errors. (That is, when the documentation disagreed with the spreadsheets, the latter controlled.) The spreadsheets did have some missing data, which required research from several informal and formal papers written by the developers as well as correspondence with the developers to determine the correct data. Inevitably we had to take some latitude in filling in blanks. Additionally, there were some terminology conflicts, where a parameter would have several different names, requiring tracing back through the spreadsheets in order to link them up. Occasionally two parameters, with different names and values, were determined to be the same parameter. In this case one of the values was selected and used through all of the simulation runs. That being said, at each test point of the model the results of the model were the same as the results of the spreadsheets, until the data was fed into the algorithms. Since the developers could not provide the results of a single round of turns, at this point the values could no longer be compared for accuracy with the spreadsheets. Ideally the results of a turn should be compared to the actual data in the region or country of game play to verify the outcomes are accurately reflecting real world events. All graphs and charts in this thesis were obtained using JMP10 software. (JMP 10, SAS Institute Inc, 2012)

<u>Set-up</u>: A control group was established and analyzed, in order to have a set of values to which to compare the results of follow-on simulations (see below). The control group consisted of 1,000 individual actions of the game (selected at random), which were

run via a computer simulation model written in Java. A seed value of 22 was selected for the random number generator (RNG) to ensure future replicability. The changes in regional PMESII values, player characteristics (hubris and influence) and resources (DIME), as well as player, NPA and region affinity values were recorded after each turn. At the beginning of each run the player's DIME and all PMESII and affinity values for players and regions were reset to the original starting values.

The following parameters, held constant in the control group, were varied in follow-on simulations to study the impact of players' choices in actions as well as the effect the moderators could have by placing limitations on the players via parameters prior to commencement of the game. Of course, future work can modify any or all of these parameters in any reasonable way.

Cost of Actions: Players are given a set amount of resources (DIME) at the start of the game. These resources are refreshed at the start of each new play, with adjustments made based on the results of the prior action. In the control group, when the RNG selected a number for an action which the player did not have sufficient resources to cover, the action was canceled. A total of 96 actions were cancelled in the control group. Figure 3 displays the counts of the cancelled actions (using the encoding scheme discussed below and Table 6). In most cases the cancellations were a result of the action cost exceeding the initial allotment of resources provided to the player. Several of the actions also have an additional affinity criterion that must be met; this affinity criterion may also have accounted for some of the cancellations. Follow-on simulations were run with player resources increased so all actions were within the range of the players' resources; however the affinity criterion was not changed.

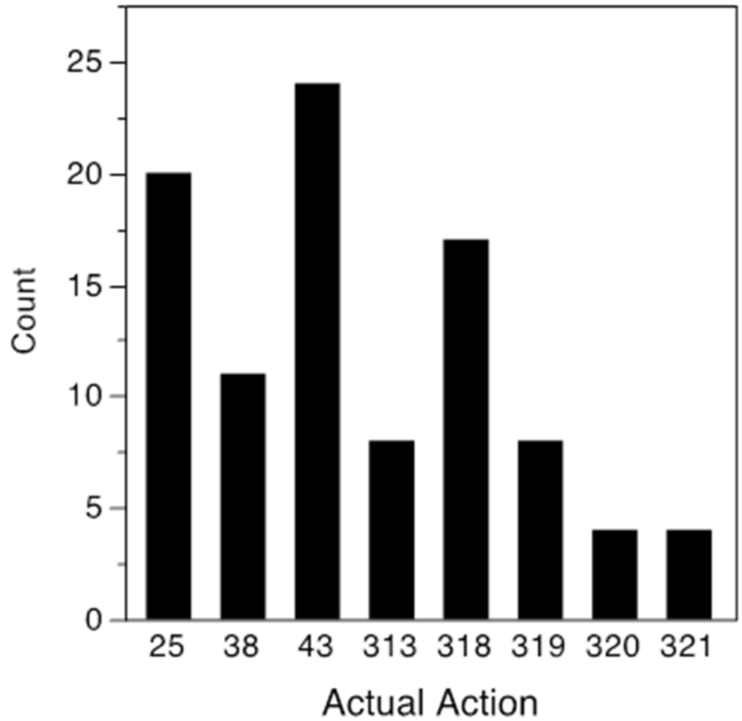

Figure 2. Bar chart representing actions (see Table 6) canceled due to insufficient resources to cover initial cost of action.

Type of action: For the control group, actions were set to run at a 25% probability of occurrence for each of the four types of actions: Diplomatic, Intelligence, Military, or Economic. These percentages were changed in follow-on simulations to evaluate the impact on PMESII and affinity values when there is a predominant type of action (e.g., making a Military action occur 50% of the time).

Optional Modifiers: Players have the option to purchase extra points for a dice roll modifier (higher values of a dice roll result in a more favorable chance of success of an action). The control group was set for the player to choose to purchase the modifier 50% of the time. Follow-on simulations tested the impact of this parameter when that probability was changed to 100%, 75%, 25% and 0%.

Regions: In the control group, actions were assigned to each of the eight regions with equal probability (12.5%). Follow-on simulations studied the impact of only one region being selected.

Proxy: For the control group it was mandated that the proxy be either the GoN or one of the NPAs with the highest affinities in each region. In regions one, two, three and eight there are two active NPAs plus the GoN; each of those entities had a 33.33% chance of selection. Since most NPAs have very low affinity values in regions four, five, six and seven, actions in those regions selected proxies from between one NPS and the GoN, each with a 50% chance of selection. Follow-on simulations changed the probability of selection to be 65% for the GoN or the NPA with the highest affinity, followed by 25% for the one second-highest affinity and 10% chance for the third, in the regions allotted the choice of three NPAs. The regions allotted two NPAs for proxies were given a 75% (for highest affinity) and 25% (for lowest) chance of selection.

Permission, Proxy, Unilateral Actions: The control group was set so that permission, proxy or unilateral actions each had a 33.33% chance of occurring. Follow-on simulations were run where:

- Permissions were not allowed
- Proxies were not allowed
- Only unilateral action allowed.
- Only permission were allowed
- Only proxy were allowed.
- Only permission or proxies were allowed.

B. ANALYSIS OF CONTROL GROUP

1. RNG Parameters

The two key parameters that change within each turn and are based on the random number generator are the region and action type. By default, both have a uniform distribution; each region and each action type have an equally likely chance of selection.

The RNG selects the actual action to be played out in the game. The action numbers arise from our encoding scheme and are not uniformly distributed themselves.

The scheme is as follows: the first digit is the type of action, where D = 1, I = 2, M = 3, and E = 4. Following the first digit the next one to two digits is the actual action numbered from one to the end (so, Military is of type 3, and since there are 24 military operations, Military actions are labeled 31, 32, 33, 34…..39, 310, 311….324). Table 6 (Ch. 3) shows all four types of actions; each type has at least six actual actions that can be selected by the random number. In Figure 3, a bar chart of the actual action that displays the action ranges with the following explanation: The different groups represent the Diplomatic actions one through six (11–16), the Intel actions one through nine (21–29), the Military actions one through nine (31–39), and the Economic actions one through nine (41–49). Note that, in the control group, action types D, I, M and E are equally likely, and each action within a type is equally likely, so, since there are only six D actions, each is chosen with probability (1/4)(1/6), whereas each of the 24 M actions is chosen with probability (1/4)(1/24). The distribution of the actual actions can be seen in Figure 3, where the blue bars are Diplomatic actions, green are Intel actions, blue are Military and black are Economic actions.

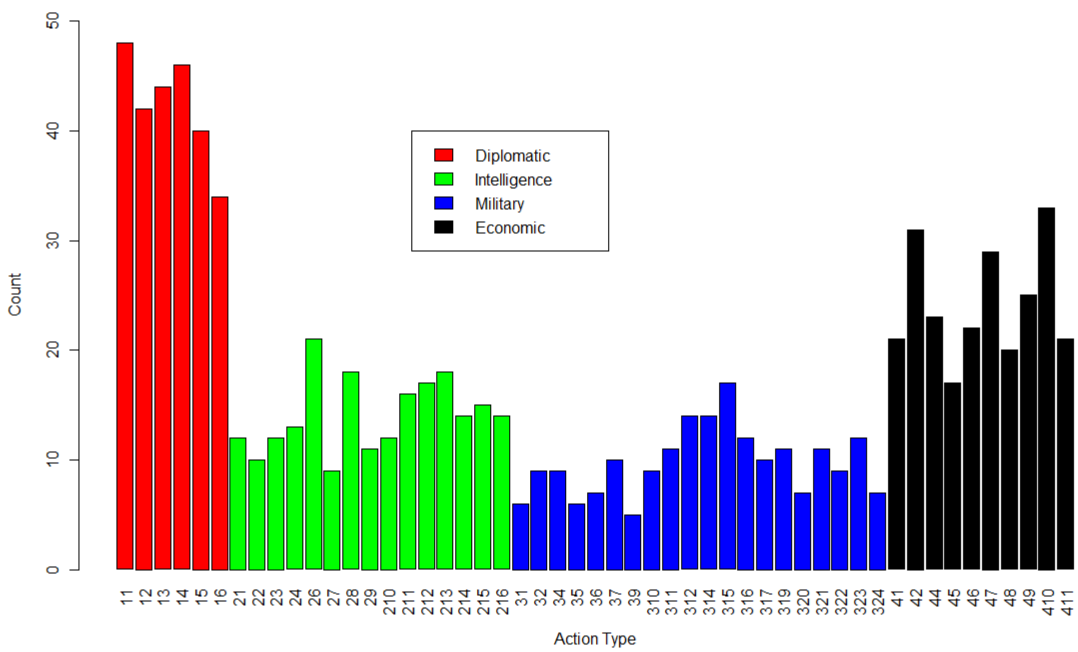

Figure 3. Bar chart representing the frequency of each of the actual actions, colored by type of actions

The results of an action are based on the roll of three fair dice. However, the developers have included modifiers that are based on the values of several different parameters. The modifiers are applied to the result of the roll of the three dice; this modified result is what determines the results of the action selected by the player. Table 7 in chapter three provides a general guideline for the result that corresponds to the value of the modified roll. Originally, the modified roll shows a distribution with two bars. This is a result of the modified dice roll being assigned an arbitrary value of 1,000 when the play is cancelled (due to lack of resources) and a value that is generally 18 or less when the play continues. The distribution of the modified dice roll is seen on the left side of Figure 4; however, once the values of 1,000 were removed the modified dice roll distribution reflected the expected normal-like distribution pattern, seen in the histogram on the right side of Figure 4. (Note that the modified value can actually exceed 18, because the modifiers are additive.) This distribution, as shown, includes the modifiers but excludes the cancellations.

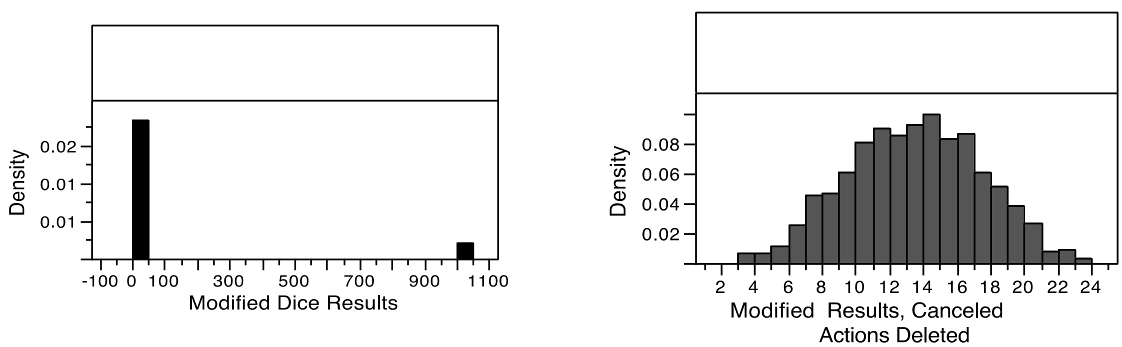

Figure 4. Side-by-side histograms of the distribution of the sum of three dice and the result of the dice roll after the modifiers are applied.

When a modified result was assigned a value of 1,000, the play was terminated and all following data for the simulation resulted in zeros. Since the zeros were the result of cancelled actions and not a result of the actual game play, we chose to delete the cancelled actions (1,000) and their associated values from the data to be analyzed. The control group therefore consisted of 904 simulation runs.

2. The Modifiers

Region modifiers are based on the PMESII values of the region and range from a value of negative three to three. Modifiers act additively on the dice rolls. In most cases the modifier is applied when a PMESII value is extreme (>2 or < –2); analysis of the data reflects that the majority of actions have a zero value for the modifier. Figure 5 shows the distribution of region modifiers in the control group. Note that most are zero, and that the –1 value is somewhat more common than the +1 value.

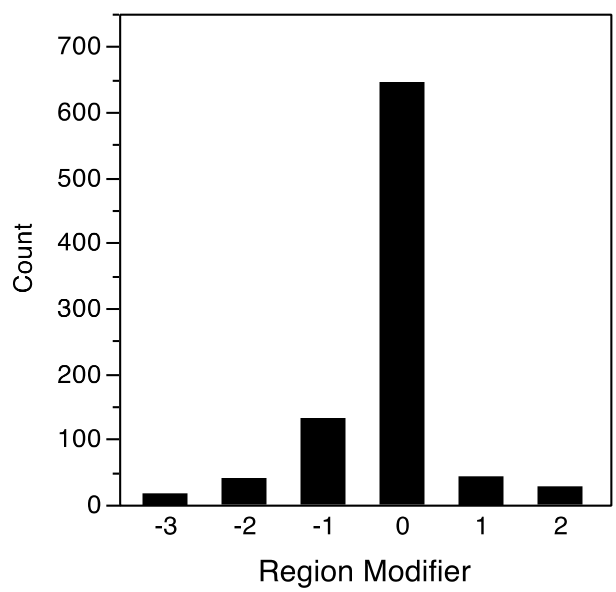

Figure 5. Control group region modifier distribution

Target modifiers are determined from a wide range of criteria: for Diplomatic actions, the modifier is affected solely by the target's affinity with the player, and can range from negative three to three with zero being the majority of modifier values. For Intel actions the modifiers range from negative ten to four; they are based on either the actual amount of Intel resources the target has acquired (for actions 21 through 28) or the target's hubris or influence values (actions 29 through 218). This accounts for the small bar at negative 10 in Figure 6. For Military actions the target modifier is determined by the target-player affinity, but the value of the modifier is often a percentage of the

Military (in DIME) value of the target. Economic action modifiers range from negative two to two. As with the Diplomatic actions, the value of zero is the most common value for Intel, Military and Economic actions, as can be seen by bar chart in Figure 6.

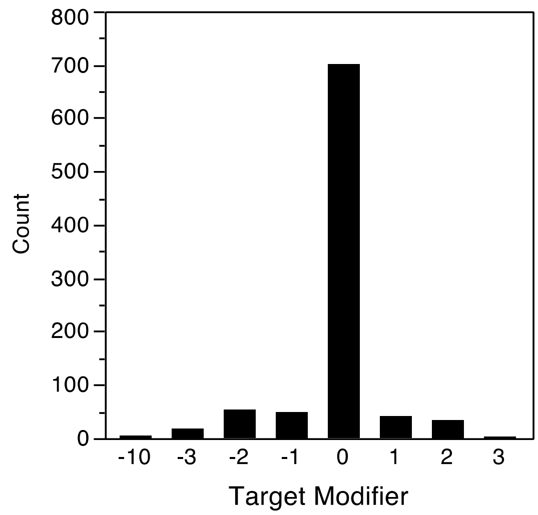

Figure 6. Control group target modifier distribution.

Since the Hubris and Influence modifiers are determined by the player's pre-existing hubris and influence points, respectively, they apply only to Diplomatic actions and to Intel action number 29. The hubris modifier ranges from negative four to zero and the influence modifier ranges from zero to four. In the control group these two modifiers take on only the values one or zero, in the case of hubris, and two or zero, for influence. This is because if the action is something other than Diplomatic or action 29 these modifiers have value zero, and the values realized for these actions are few since the players' hubris and influence points are reset to the original values at the start of each turn. These distributions will reflect a wider range of values when players' starting points differ from turn to turn.

The "other" modifier is determined by the number of facilities a player owns, as well as whether the action is covert or overt. Owning a facility provides a player with resource points (e.g., a factory gives a player three additional points for his or her Economy score). The facility also provides a modifier for each action that is taken that is of the same type. So if a CIA station is established, a player will receive five Intel points every turn, and, on every turn that is type Intel, will receive five modifier points on the dice roll total. Additionally, if a play is covert, a modifier of one is added to the dice roll. These distributions would be expected to change with continuous play. For the control group, the player started with one CIA station and one embassy. Figure 7 (left panel) reflects the distribution of the "other" modifiers.

The "option" modifier allows the player to buy modifier points using their DIME resources for some actions. In the control group, the probability that players were permitted to buy modifier points was set at 50%. Players with permission still needed to have sufficient resources to buy points. Some actions permit differing numbers of points to be bought; in those cases an additional random number selected the number of option points. Figure 7 (right panel) shows the distribution of "option" points purchased in the control group.

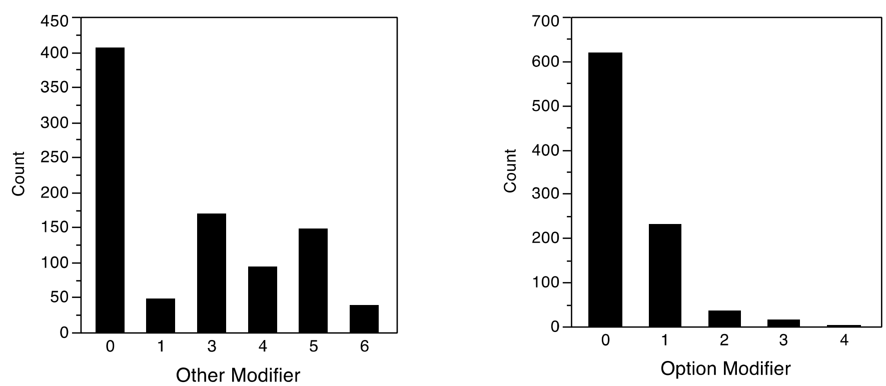

Figure 7. "Other" modifier distribution and "option" modifier distribution.

3. Results

There are numerous types of result from the GCM that can be examined. The outputs from a turn act as intermediate results, since they are then used in the underlying algorithm to predict the PMESII and affinity changes. However, they are of interest in themselves, since they help determine whether the model is acting as intended. Two intermediate results are the average size of the action, ranging from one to five, with one being extra small and five being extra large, and the impact of the action, with negative one representing a negative impact, zero being neutral, and one being a positive impact. Figures 8 and 9 show the distributions of actions sizes and impacts in the control group. Actions of "extra small" size are seen to be rare, and most of the actions had a positive impact.

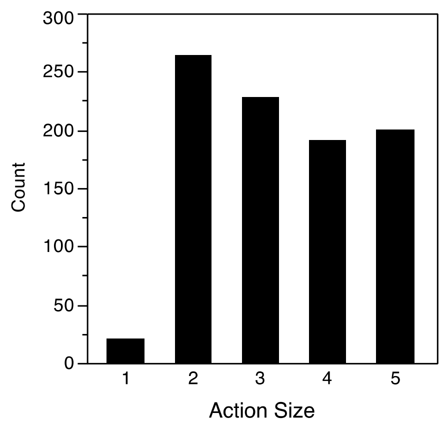

Figure 8. Distribution of action size, ranging from one (extra small) to five (extra large)

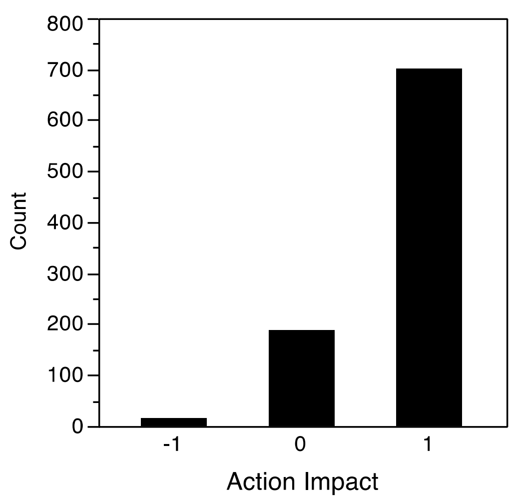

Figure 9. Impact values, where negative one is a negative impact, zero is neutral and one is a positive impact

Three other intermediate results of an action are (1) permission, (2) proxy request, and (3) no request for permission or proxy. Each of these has a 1/3 chance of being selected in the control group. Figure 10 displays the results of these requests. The column marked “1” shows permissions requested and granted, “2” shows permission requested and declined, “3” shows proxies requested and accepted, “4” shows proxies requested and declined, and “5” shows unilateral actions (in which no permission or proxy was requested). Once the option is selected by the RNG, the permission, and proxy equations given in chapter three are utilized to determine the results of the requests.

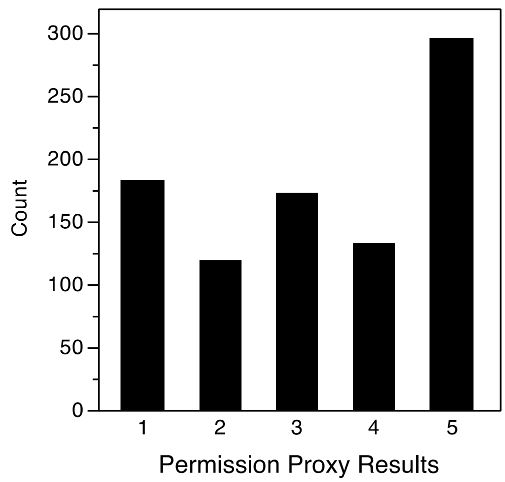

Figure 10. Distribution of permission (1 and 2), proxy (3 and 4), and unilateral (5) actions

4. Analysis of the Target

Since most actions have a positive impact (Figure 9), we expect to see an increase in target, player affinity and target, hearer affinity most of the time. Figure 11 is a scatter plot matrix of the impact of an action versus change in affinity between the target and requestor (left panel), and between the target and hearer (right panel). As expected, there is an increase in affinity (points above zero) for the positive and neutral results and a slight decrease in affinity in the negative impact actions. Some positive actions can produce negative changes in affinity.

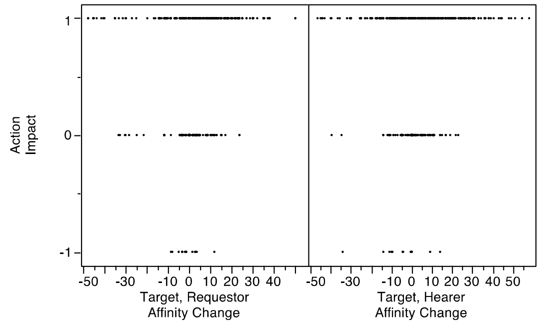

Figure 11. Impact vs. change in affinity of the target and requestor (left panel) and target and hearer (right panel).

When the affinities between the target and NPAs, on the one hand, and the player, on the other, improve, it is expected that in general "good will" may be reflected positively in the affinity of the target and the region. This is supported in Figure 15, where we can see that as the target-player (left panel) and target-hearer affinity (right panel) increase, the target-region affinity also has a small trend upward.

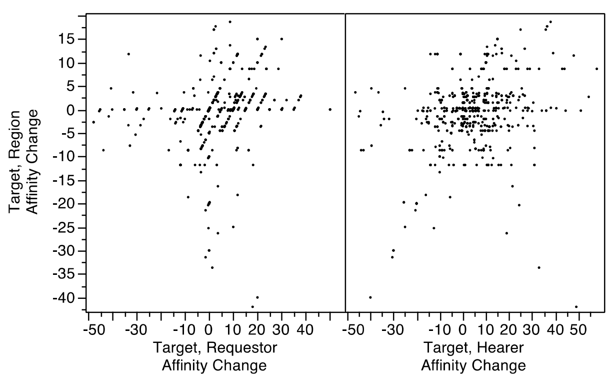

Figure 12. Target-region affinity versus target-player (left panel) and target-hearer affinity (right panel)

The relationships between target affinity and the results of a permission, proxy or unilateral request can be seen in Figure 13. The general trend in Figure 13 appears to be that when a permission or proxy is requested and approved or accepted the affinity between the two players increases and when declined or denied, the affinity decreases. As before, permission requested and granted is represented by the value "1," and denied by a

"2." The target-playerplot (left panel) shows an increase and decrease in affinity respectively as expected. Proxies requested and accepted are shown as "3" and those denied is "4"; the target-hearer plot (right panel) reflects similar results. A unilateral action is represented by line five, and there does not appear to be any definitive trend in any of the scatter plots. In this model, there is no direct linkage between the target-region affinity and the result of a permission or proxy request; this is reflected in the center panel of Figure 16.

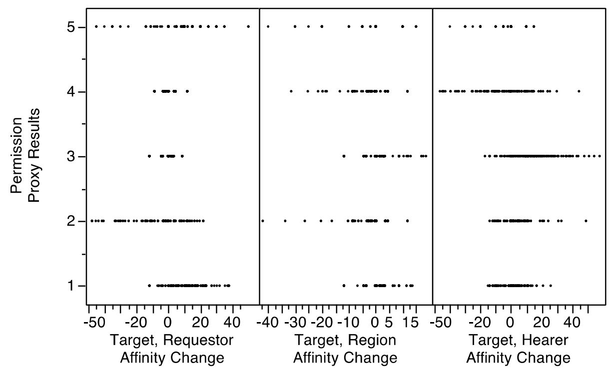

Figure 13. Scatterplots of target affinities vs. permission, proxy and unilateral actions.

5. Analysis of Player Characteristics and Resources

Player characteristics (hubris and influence) change based on the results of an action, which is in turn determined by the final modified dice roll. Although the values for each result vary with each action, Table 5, in chapter three, provides a general average range for all actions and the corresponding results of the modified dice roll. In theory, it would be expected that successful actions would tend to increase the influence and decrease the hubris of a player. Although for many actions there are no changes in these values, overall there should be a general trend in the appropriate direction. Figure 14 shows an increase in influence with successful results (modified roll greater than 12) and an increase in hubris with unsuccessful results (modified roll less than 8), both of which support the expected theory. Also of note is that hubris is affected by the failure to gain permission or proxy upon request. Figure 15 shows changes in influence (for the starting value of 20) and of hubris (from 15) for permission and proxy requests ("2" and "4" corresponding to permission denied and proxy declined, respectively). The figure shows that an increase in hubris and a decrease in influence for denials and declines, and an increase in influence and a decrease in hubris for approvals and acceptances.

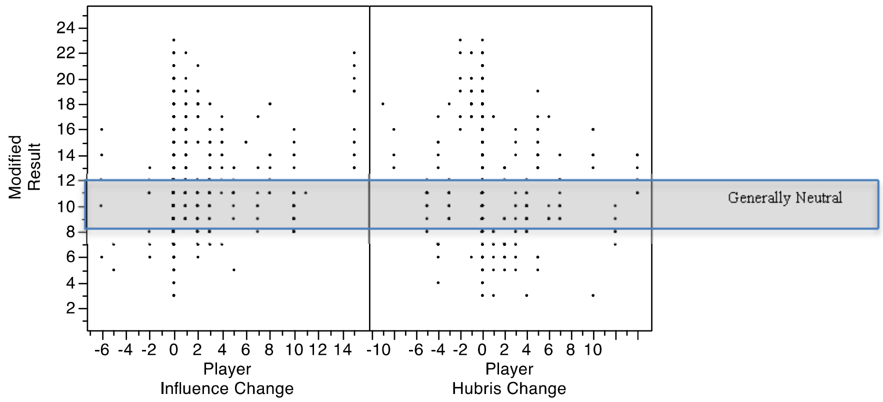

Figure 14. Modified results versus player influence and hubris changes.

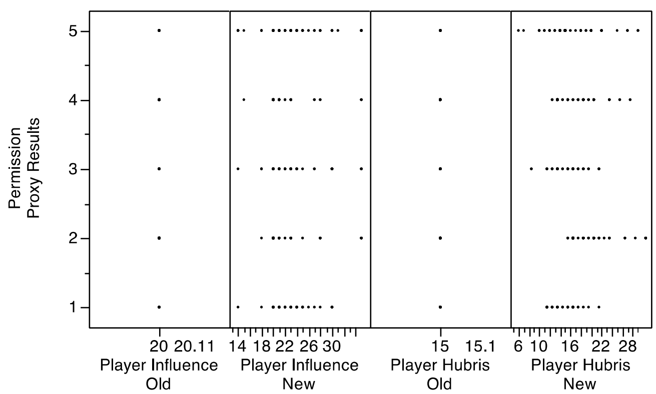

Figure 15. Player hubris versus permission, proxy, unilateral results (un-jittered).

Player resources are used to pay for an action, so there should be a decrease in player resources for each type of action. Figure 16, which shows the old and new DIME values, indicates a decreasing trend in each of the new values. Some Economic actions show an increase in values after an action, because when an Economic action succeeds, it awards increases in the player's E values.

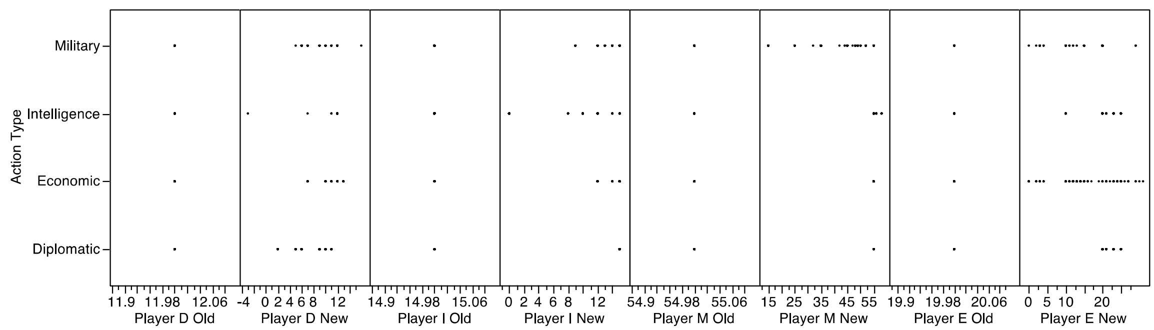

Figure 16. Action type versus old and new player DIME values (un-jittered)

Since the majority of the actions have a positive impact, it is expected that the control group should see an increase in affinity for the player in each region as well as with the target and the hearer. Figure 17 shows the changes in player affinity for the action type (far left plot), with each region (center left plot), with the targets (center right plot) and with the kingpin, otherwise known as hearer (far right plot). The player versus action type plot shows that the majority of actions result in a ten- to twenty-point increase in affinity for the player, which can also be seen in the player's affinity increase in each region, with each target and with each hearer. The sparse data in the MEND column of in the player versus hearer plot) is due to the fact that MEND can be a hearer in only the SE region, and even then only has a 1/3 chance of being selected. In contrast, Thugs can be a hearer in three regions, IMN and Church in four regions, and GoN can be selected in all 8 regions.

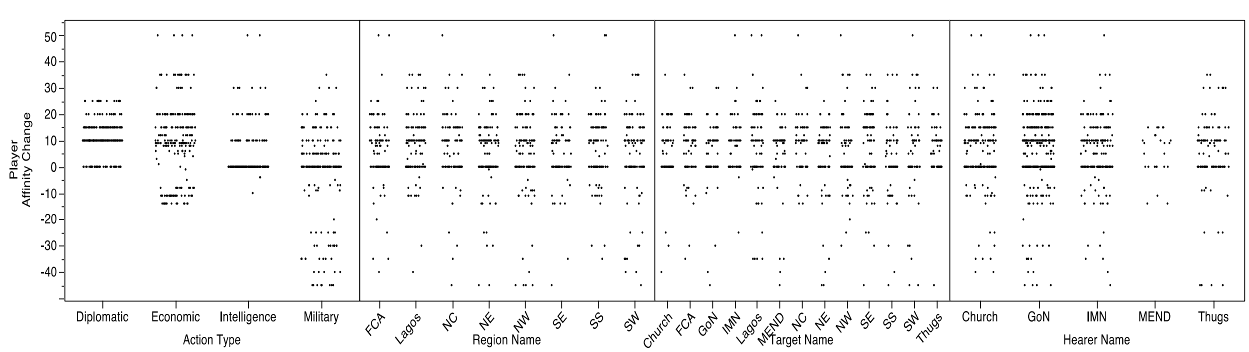

Figure 17. Changes in player affinity

6. Region analysis

Figure 18 shows the affinity changes experienced by the control group by region. In each of the “Affinity New” panels a forward trend to higher affinity can be observed. These are compared with the results of follow-on tests in order to compare the trends following the completion of an action.

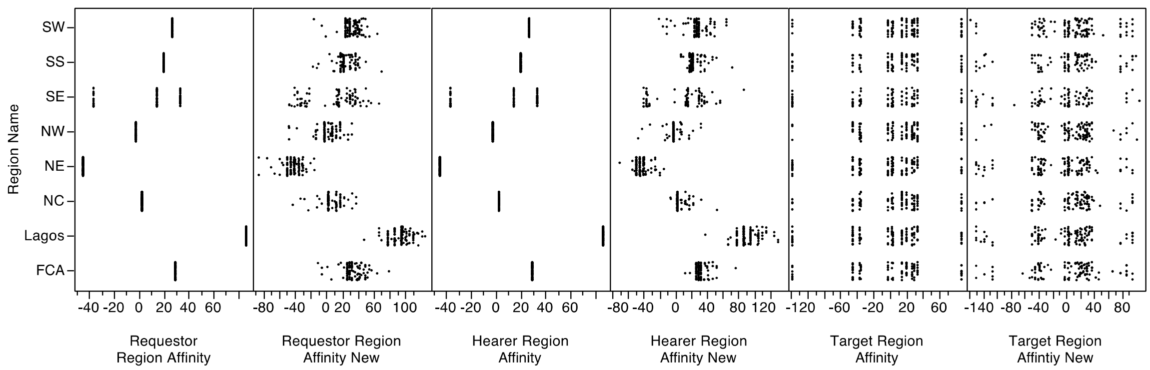

Figure 18. Region starting affinity and ending affinity (jittered)

Tables 8 through 10 show the summary statistics for the changes in PMESII values in the region where the action took place. (The column headers correspond to the entries on pages 19 and 20.) The “info” column shows the change in information; in this version of the game there are no action results that affect the information resource. Table 8’s entries show the mean changes; Table 9, the corresponding standard deviations; and Table 10, the maximum and minimum changes.

Table 8. Region PMESII mean change values

Region	N	P (Mean)	M (Mean)	E (Mean)	S (Mean)	Info (Mean)	Infra (Mean)
NW	118	0.000	–0.059	1.644	1.576	0	0.229
NE	136	–0.419	–0.007	0.721	1.029	0	0.117
NC	102	0.068	0.686	2.627	2.451	0	0.716
FCA	109	–0.027	0.514	2.193	1.037	0	0.376
Lagos	125	0.424	0.200	2.312	2.168	0	0.536
SW	120	0.491	0.092	1.725	0.550	0	0.158
SS	103	0.476	0.893	1.019	1.068	0	0.340
SE	91	0.033	0.637	1.934	0.637	0	0.033

Table 9. Region PMESII Std Deviation values

Region	N	P (Std Dev)	M (Std Dev)	E (Std Dev)	S (Std Dev)	Info (Std Dev)	Infra (Std Dev)
NW	118	4.887	1.434	10.408	9.667	0	2.957
NE	136	4.233	1.021	8.705	7.343	0	1.936
NC	102	4.614	5.592	10.344	8.235	0	3.457
FCA	109	3.510	5.329	7.665	8.367	0	2.497
Lagos	125	3.699	1.576	9.585	6.968	0	2.330
SW	120	5.372	1.749	9.508	8.717	0	2.487
SS	103	4.650	5.750	8.241	6.694	0	2.487
SE	91	4.557	5.853	9.857	6.641	0	3.063

Table 10. Region Min Max PMESII change values

Region	N	P (Min/Max)	M (Min/Max)	E (Min/Max)	S (Min/Max)	Info (Min/Max)	Infra (Min/Max)
NW	118	–20 / 25	–5 / 10	–25 / 35	–30 / 22	0 / 0	–10 / 10
NE	136	–20 / 25	–5 / 6	–30 / 35	–30 / 30	0 / 0	–10 / 10
NC	102	–20 / 15	–5 / 55	–25 / 55	–30 / 30	0 / 0	–10 / 20
FCA	109	–20 / 15	–4 / 55	–25 / 35	–23 / 60	0 / 0	–8 / 20
Lagos	125	–20 / 15	–3 / 10	–20 / 35	–22 / 30	0 / 0	–4 / 10
SW	120	–20 / 25	–5 / 10	–25 / 35	–30 / 30	0 / 0	–10 / 10
SS	103	–20 / 25	–4 / 55	–21 / 30	–23 / 30	0 / 0	–8 / 20
SE	91	–20 / 15	–5 / 55	–25 / 35	–30 / 30	0 / 0	–10 / 20

C. DESIGN OF THE FOLLOW-ON SIMULATIONS

1. Increasing Resources

The purpose of this follow-on simulation was to evaluate the impact of increased resources. A simulation run of 1,000 actions, and an RNG seed value of 22 was run on which player resource points were increased to a value that met or exceeded all action costs available. We expect fewer cancellations, since most of these result from insufficient resources; of course, we do expect some cancellations because of the affinity criterion. Figure 19 displays the results of this simulation; and analysis confirmed the expected results of this test; the number of cancelled actions decreased from 96 to 16. (The right panel shows the actions after removing the ones cancelled for lack of resources; a small number of cancellations is still visible.)

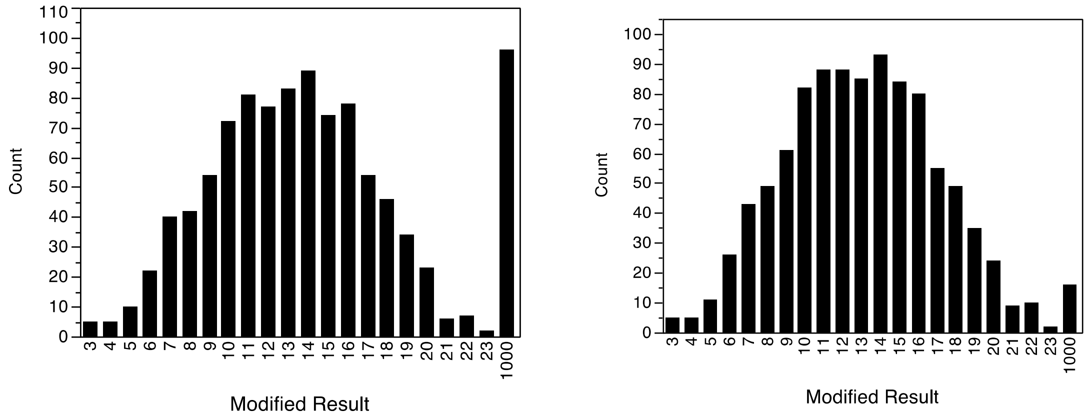

Figure 19. The left panel displays the results of the action with limited resources from the control group; the panel on the right is the result of a player with enough resources to cover any action.

Figure 20 shows the actions that were cancelled. We see that the identified action cancellations are indeed a result of constraints set by the affinity criterion, rather than resource limitations.

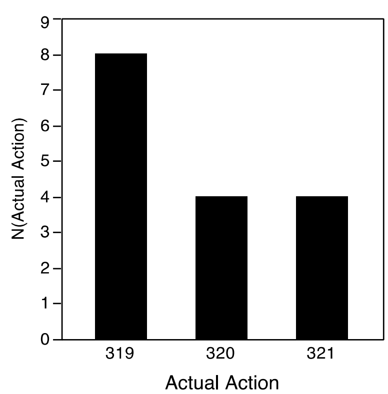

Figure 20. Distribution of actual actions cancelled, from the simulation run with increased resources

2. Increasing and Decreasing the Probability of Occurrence of Type of Actions

To test the effects of changing the probability of a particular type of action, one simulation of 1,000 turns and an RNG seed value of 22 provided the results shown in

Table 11. Actions cancelled because of the affinity criterion were discarded. In each case one probability was changed, and the other possible random outcomes were given equal probabilities of occurrence. For example, in Test 1, a Diplomatic action was chosen with probability 0.5, and Intel, Military, and Economic actions chosen with probability 16.7% each. Probabilities were set in the different tests as shown in the "Prob D" and corresponding rows of Table 11.

Table 11. Parameter changes as a result of changing the probability of one type of action

Parameter	Control	Test 1	Test2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8
Number of cancellations	96	53	75	126	89	32	72	152	80
Prob D	25%	50%	17%	17%	17%	75%	8%	8%	8%
Prob I	25%	17%	50%	17%	17%	8%	75%	8%	8%
Prob M	25%	17%	17%	50%	17%	8%	8%	75%	8%
Prob E	25%	17%	17%	17%	50%	8%	8%	8%	75%
Size of Action (mean)	3.317	3.273	3.249	3.205	3.659	3.243	3.187	3.064	3.960
Impact of Action (mean)	0.759	0.799	0.768	0.665	0.830	0.811	0.755	0.573	0.898
Permission Requested and granted	182	212	160	190	212	233	113	173	213
Permission requested and Denied	119	105	150	109	96	91	196	113	94
Proxy Requested and Accepted	174	186	143	168	200	218	123	173	230
Proxy Requested and Declined	133	131	168	125	110	108	190	114	88
Unilateral Action	296	313	304	282	293	318	306	275	295
Target Affinity change	–0.623	–0.354	–1.351	–0.463	–0.557	–0.260	–2.336	0.009	–0.188
Player Affinity Change	5.864	7.669	5.232	3.288	7.305	9.939	4.957	1.018	9.198

Target Hubris Change	–0.027	–0.045	–0.068	0.007	0.006	–0.004	–0.075	–0.018	–0.016
Player Hubris Change	0.475	0.225	0.195	0.713	0.314	0.023	–0.041	1.068	0.287
Target Influence Change	0.485	0.288	0.368	0.236	1.080	0.188	0.310	–0.044	1.665
Player Influence Change	1.210	0.890	1.195	1.101	1.211	0.611	1.251	1.226	1.451
Target-Hearer Affinity change	2.486	3.079	2.274	1.845	3.083	3.934	2.094	1.516	3.851
Requestor-Region Affinity Change	4.175	5.627	3.475	2.478	5.239	7.351	3.177	0.728	6.434
Hearer-Region Affinity Change	2.404	2.772	1.648	1.332	2.863	3.873	1.278	0.701	3.658
Requestor-Target Affinity Change	3.676	5.280	3.495	1.953	4.689	6.693	3.657	0.581	6.092
Target-Region Affinity Change	–0.764	–0.336	–1.386	–0.728	–0.709	–0.275	–2.107	0.067	–0.083
Player D Change	–1.830	–2.867	–1.345	–1.614	–1.372	–3.975	–0.919	–1.450	–1.088
Player I Change	–1.898	–1.302	–3.4	–1.547	–1.317	–0.470	–4.811	–1.164	–0.889
Player M Change	3.70	–2.495	–2.502	–7	–1.755	–0.791	–0.725	–10.511	–0.9
Player E	1.700	–0.633	–0.822	–1.763	–3.223	0.308	–0.060	–2.154	–4.759

Change									
Region P Change	0.123	–0.045	–0.041	–0.158	0.853	0.090	0.061	–0.550	1.327
Region M Change	0.336	0.141	0.145	0.223	0.629	0.116	0.121	0.322	0.866
Region E Change	1.743	1.219	1.251	1.675	3.207	0.620	0.706	1.532	4.847
Region S Change	1.321	0.941	0.971	0.748	3.396	0.660	0.714	0.120	5.087
Region Info Change	0	0	0	0	0	0	0	0	0
Region Infrastructure Change	0.354	0.220	0.225	0.205	0.772	0.131	0.158	0.081	1.165

3. Changing the Probability of Proxy Selection

In the next set of simulations the probability of NPA proxy selection was changed in order to observe parameter changes. In the control group each of the two or three NPAs had an equal chance of being selected. For this simulation the NPA with the highest affinity was given a 65% chance of selection, then next highest affinity was given a 25% chance of selection and the third a 10% chance. In the event only two NPAs were available for selection the probabilities were changed to 75% and 25%. Table 12 summarizes the mean change in parameters and variables.

4. Allowing Only One Region

For this simulation, the player was not given a choice of regions. All turns occurred in the same region. For this simulation the region NW was arbitrarily chosen and Table 12 reflects the changes in parameters and variables that resulted.

5. Changing the Option Modifier

The GCM has several actions where the player is given the option to purchase modifier points to improve the value of the dice roll. The control group was set so the player had a 50% chance to select the modifier. Four follow-on simulations of 1,000 actions and a seed value of 22 were run to examine the results of changing the player's ability to select and purchase the option modifier. The probability of selecting the option modifier was set to 0%, 25%, 75% and 100%. It should be noted that as with the control group, even if the player chose to purchase the option modifier, if the resources were not available then the modifier could not be used.

Table 12. Mean results of simulations 9–16

Parameter	Control	Test 9	Test 10	Test 11	Test 12	Test 13	Test 14
Number of Cancellations	96	96	96	96	96	96	96
Condition		Proxy change	Region NW	No option	Option 25%	Option 75%	Option 100%
Size of Action (mean)	3.318	3.315	3.315	3.315	3.315	3.315	3.315
Impact of Action (mean)	0.759	0.759	0.771	0.727	0.740	0.763	0.770
Permission Requested and Granted	182	183	179	183	183	183	183
Permission Requested and Denied	119	119	123	119	119	119	119
Proxy Requested and Accepted	174	173	159	173	173	173	173
Proxy Requested and Declined	133	133	147	133	133	133	133
Unilateral Action	296	296	296	296	296	296	296
Target Affinity Change	–0.623	–0.623	–0.637	–0.576	–0.598	–0.639	–0.616
Player-Affinity Change	5.864	5.820	6.101	5.493	5.581	6.084	6.173
Target Hubris Change	–0.027	–0.0267	–0.027	–0.045	–0.033	–0.021	–0.023
Player Hubris Change	0.475	0.475	0.471	0.485	0.478	0.458	0.449
Target Influence Change	0.485	0.476	0.400	0.438	0.452	0.479	0.489
Player Influence Change	1.210	1.206	1.315	1.156	1.187	1.239	1.258
Target-Hearer Affinity Change	2.486	2.291	2.296	2.376	2.402	2.540	2.601
Requestor-Region Affinity Change	4.175	4.134	3.943	3.950	4.000	4.314	4.354

Hearer-Region Affinity Change	2.404	2.298	2.122	2.264	2.302	2.491	2.540
Requestor-Target Affinity Change	3.676	3.710	3.775	3.449	3.499	3.813	2.540
Target-Region Affinity Change	–0.764	–0.741	–0.824	–0.717	–0.739	–0.780	–0.756
Player D Change	–1.829	–1.829	–1.846	–1.837	–1.832	–1.834	–1.852
Player I Change	–1.898	–1.897	–1.896	–1.880	–1.891	–1.886	–1.869
Player M Change	–3.700	–3.711	–3.705	–3.768	–3.723	–3.691	–3.684
Player E Change	1.700	–1.662	–1.659	–2.454	–2.060	–1.211	–0.884
Region P Change	0.123	0.112	0.082	0.022	0.120	0.140	0.127
Region M Change	0.336	0.336	0.327	0.342	0.340	0.340	0.338
Region E Change	1.743	1.691	1.712	1.648	1.683	1.716	1.737
Region S Change	1.321	1.308	1.176	1.274	1.259	1.288	1.272
Region Info Change	0	0	0	0	0	0	0
Region Infrastructure Change	0.354	0.332	0.306	0.337	0.336	0.334	0.327

6. Changing the Options to Request Permission and Proxies

Five simulations of 1,000 actions and a seed value of 22 were run to test the impact of permissions and proxies. Every action either requires the player to seek permission (indicated by “Pe” in Table 13), request a proxy (“Pr”), or act unilaterally (“U”). The “Pe,Pr,U” row of Table 13 shows the results of these simulations. For example, the “0, .5, .5” in the “Pe, Pr, U” row of Test 15 shows that, in those simulations, players were not allowed to ask for permission, whereas proxies and unilateral actions each were given a 50% probability of occurrence.

Test 16: Player was not allowed to ask for a proxy. Permissions and unilateral actions were given a 50% probability of occurrence.

Table 13. Mean results of simulations 15–19

Parameter	Control	Test 15	Test 16	Test 17	Test 18	Test 19
Number of Cancellations	96	96	96	96	96	96
Pe, Pr, U	.33, .33, .33	0, .5, .5	.5, 0, .5	0, 0, 1	1, 0, 0	0, 1, 0
Size of Action (mean)	3.31747	3.31526	3.31526	3.31526	3.31526	3.315265
Impact of Action (mean)	0.759	0.759	0.759	0.759	0.759	0.7589
Permission Requested and Granted	182	0	272	0	541	524
Permission Requested and Denied	119	0	187	0	363	0
Proxy Requested and Accepted	174	252	0	0	0	0
Proxy Requested and Declined	133	197	0	0	0	380
Unilateral Action	296	445	445	904	0	0
Target Affinity change	-0.623	–0.623	–0.623	–0.623	–0.623	–0.623
Player Affinity Change	5.863	5.820	5.820	5.820	5.820	5.820
Target Hubris Change	–0.027	–0.027	–0.027	–0.027	–0.027	–0.027
Player Hubris Change	0.475	0.475	0.475	0.475	0.475	0.475
Target Influence Change	0.485	0.476	0.476	0.476	0.476	0.476
Player Influence Change	1.210	1.206	1.206	1.206	1.206	1.206
Target-Hearer Affinity Change	2.429	2.38	0.991	–0.622	2.427	5.351
Requestor-Region Affinity Change	4.175	3.133	6.028	5.820	6.337	0.579
Hearer-Region Affinity	2.352	3.160	0.208	0	0.517	6.399

Change						
Requestor-Target Affinity Change	3.676	2.833	5.787	5.820	5.769	–0.104
Target-Region Affinity Change	–0.764	–0.686	–0.656	–0.623	–0.673	–0.726
Player D Change	–1.830	–1.829	–1.829	–1.829	–1.829	–1.829
Player I Change	–1.898	–1.897	–1.897	–1.897	–1.897	–1.897
Player M Change	3.700	–3.711	–3.711	–3.711	–3.711	–3.711
Player E Change	1.700	–1.661	–1.661	–1.661	–1.662	–1.662
Region P Change	0.123	0.112	0.112	0.112	0.112	0.112
Region M Change	0.336	0.336	0.336	0.336	0.336	0.336
Region E Change	1.743	1.691	1.691	1.691	1.691	1.691
Region S Change	1.321	1.308	1.308	1.308	1.308	1.308
Region Info Change	0	0	0	0	0	0
Region Infrastructure Change	0.354	0.332	0.332	0.332	0.332	0.332

D. ANALYSIS OF FOLLOW-ON SIMULATIONS

1. Comparing Control and Follow-on Tests

In this section, we discuss the results of comparing the test conditions described above with the control condition. Changes in region PMESII values are discussed at the end of this chapter.

Recall from earlier chapters that each set of simulations started with the RNG set to a common value. Each individual simulation receives the same number of random variates, so, for example, the 234th simulation of the control group and the 234th simulation in each of the test groups are provided the same random variates. In this sense, the control group and the test groups are “blocked” by replication number. However, the usual analysis for matched pairs or blocks is inappropriate here because of the way the random variates are incorporated into the model. As an example, compare the selection of DIME action in the control case (in which each of the four types of actions is equally likely) to the case of Test 1 (in which Diplomatic actions take place with probability 50%, and each of the other three takes place with probability 16.7%). In the control group, the action is selected by comparing the random variate to the set of cut-points (.25, .50, .75). If the variate is smaller than .25, a Diplomatic action is selected; if it is between .25 and .50, an Intel action is selected, and so on. In the Test 1 case, the same number is generated. It is then compared to the set of cut-points (.50, .67, .83). Therefore, every action of type D in the control group corresponds to an action of type D in the Test 1 group, and every Test 1 action of type E maps back to a control group action of type E. The selection of the action is the only thing differentiating these two groups, and, since the action coincides on half of the plays, we know that the results will coincide with probability 0.5.

In every one of our tests, the control and test groups have some substantial probability of producing the exact same results. In practice, of course, the results of simulations will have much more variability, since differing seeds for the RNG will be employed. In that case the usual *t*-test for differences in means between control and test conditions, or for analysis of variance, might be appropriate. The randomness in that model would then arise from the choice of individual variates across all seeds. By choosing common random numbers, we have much less variability in our results – but the assumptions of the paired *t*-test are not met. Our goal is not to perform statistically valid tests; instead it is to provide a framework to allow the game to be run many times, automatically and repeatably. Within this framework developers will be able to modify starting values, action availabilities and other parameters of the game with an eye toward increasing its validity, and to use the automatic nature of our framework to seek inputs intended to optimize some measure of success.

Below we analyze the results from running the model under the test conditions. In some cases we have used paired *t*-tests simply for interpretability, taking p-values as rough effect size measures, rather than as strict probability statements that concern the plausibility of null hypotheses.

2. Test 1 through Test 8 Results

Number of Cancellations: The control group had 96 cancellations, which was 9.6% of the total actions. For each test, except Military actions, the number of cancellations decreased. For Diplomatic actions there are two large actions; the cost of both was within the amount of resources allotted to the player, so in theory increasing Diplomatic actions should decrease the number of cancellations. In Test one the number of Diplomatic actions was increased to 50%; this decreased cancellations to 5.3%. Increasing the number of Diplomatic actions to 75% decreased cancellations to 3.2%. For Intel actions there is only one action that the player does not have resources to cover on an initial turn. When Intel actions were increased to 50%, cancellations decreased to 7.5% of the total and when increased to 75%, cancellations decreased to 7.2% of the total actions. There are several Intel actions which have affinity criteria that must be met; this affects the number of cancellations. Military actions saw an increase in cancellations. There are three Military actions unavailable to the player due to the cost exceeding the player's resources on the first turn. Increasing the Military actions to 50% saw an increase to 12.6% of total actions, and increasing Military action to 75% increased the total cancellations to 15.2% of the total actions. Economic actions have one action that is unavailable to the player. Increasing Economic actions to 50% decreased total cancellations to 8.9%, and increasing Economic actions to 75% saw a further decrease in cancellations to 8.0%

Size of Actions: From Table 11 we can see that in six of the eight tests the average size of actions decreased compared to the control group. Test 4 and Test 9 (both Economic action increases) showed increased sizes. The increases arose because the majority of Economic actions are either large or extra large in size, and they often impact the whole region (e.g., build a factory, impose sanctions, or impose tariffs). Out of the eleven possible Economic actions only three are size medium or smaller.

Impact of Action: The average impact of an action for the control group was 0.755, on a scale ranging from negative one for a negative impact to 0 for neutral and one for a positive impact. As discussed previously, the majority of plays resulted in a successful action, which in turn positively impacted the region and players. From Table

11 we can see that the results of Tests 3, 6, and 7, were less than those in the control group, but still positive, and that the rest of the test groups showed a greater positive impact than the control group. In theory this should produce greater affinity between player and regions.

There is a substantial correlation between mean action size and mean impact of action. Figure 21 shows the mean sizes and impacts for the control group and the eight test groups. (This is, then, an ecological correlation across a thousand or so replications; it might be valuable to further researchers to examine the individual values.) Also shown is the best-fitting line and a confidence interval for that line. This correlation, of size 0.77, indicates that, on average, the bigger the action, the greater the impact, at least in these test-wide means.

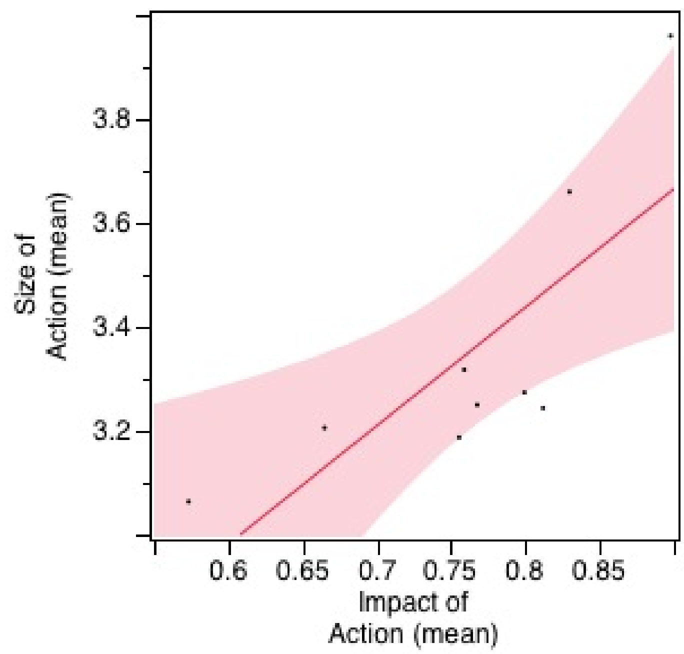

Figure 21. Test for correlation and multicolinearity between size so action and impact of action.

Permission, proxy, and unilateral actions: in the control group, 182 actions involved permission being requested and granted; actions in which permission was requested and denied numbered 119; there were 174 proxies requested and accepted;

133 proxies requested and declined; and 296 unilateral actions. In the test groups both of the tests in which the probability of an Intel action was increased saw a very high rate of rejections for permissions and proxies. This is possibly a direct reflection of the very low benefits allotted to all players for an Intel action. Player benefit values are utilized by the game's artificial intelligence, and contribute to the permission and proxy equations. This should be investigated in follow-on studies.

Player affinity, hubris and influence: In the control group the player mean affinity value was 5.86, player hubris was 0.475 and player influence 0.485. In Tests 1, 4, 5 and 8 player affinity was higher than in the control group and in Tests 2, 3, 6, 7, it was lower. However, in all tests the average player affinity remained positive and increased in value. The mean player affinity increased by as much as 9.9 points; the maximum increase in hubris was 1.06; and the maximum increate in influence was 1.45. Hubris increased far less than affinity and is representative of the actions that failed. With the clearly positive impact of action averages, it can be concluded that many more actions succeeded than failed, which accounts for the large difference between affinity increases and hubris increases. These tests demonstrate that the positive and negative impact of actions successfully carries over to the affinity of a player and the player's corresponding characteristics. As with hubris values, the influence values increased much less than the affinity value increases. Follow-on tests should investigate the small increase in influence; in theory this value should increase more along the lines of affinity values with the large number of actions resulting in a positive impact.

Affinity relationships between the target, hearer (kingpin), requestor (player) and region: In each of the following relationships there was a positive affinity change for each of the tests: target-hearer, requestor-region, hearer-region, requestor-target. This is attributed to the overall positive impact of the actions and thus relationships improved between the two entities. There was a decrease in affinity in the target and region relationship, which is a bit unexpected, but still within reason based on the small values of target-region affinity that was seen in the control group.

Player resources (DIME): These values were examined in order to ensure that the model was adequately deducting resources for an action while also adding in resource points obtained as a reward for a successful action. Table 14 was obtained from the game's settings, and displays the average costs of each of the four types of actions. Of interest is that numerous Military and Economic actions cost more than just Military and Economic resources. The large standard deviations are also worthy of note.

Table 14. Average action costs, obtained from game settings established by SME

Type of Action	Code	Average Costs (deducted)	StdDev	Avg Resources (received)	StdDev
Diplomatic	D =	– 4.83	3.43	3.00	0
Intel	I =	– 8.44	5.75	– 3.25	1.54
Military	D =	– 2.05	4.15	2.50	17.1
	I =	– 2.67	2.08		
	M =	– 22.2	21.2		
	E =	– 6.12	6.12		
Economic	D =	– 2.75	1.71	1.97	3.52
	I =	– 2.75	1.00		
	E =	– 6.12	13.6		

Comparing these values to the values that occurred in the test simulations: The top-shaded block in each column of Table 15 represents a 50% increase in the type of action that corresponds to that resource. The bottom-shaded block represents the 75% increase in that type of action. As expected the increased number of actions resulted in increased expenditures of that type of resources, which can be seen when comparing the shaded blocks to the control group. This lends some measure of validation to the intent of the game's designers. Also of note is that each of the mean values is within one standard deviation of the means obtained from the game settings.

Table 15. Table of player resources after conducting Tests 1–8, top shaded number in each column is 50% increase and the bottom number is 75%.

Test	D Changes	I Changes	M Changes	E Changes
Control	– 1.830	– 1.898	3.700	1.700
50% Diplomatic	– 2.867	– 1.302	– 2.495	– 0.633
50% Intel	– 1.344	– 3.400	– 2.501	– 0.822
50% Military	– 1.614	– 1.547	– 7.000	– 1.763
50% Economic	– 1.372	– 1.317	– 1.755	– 3.222
75% Diplomatic	– 3.975	– 0.470	– 0.791	0.308
75% Intel	– 0.919	– 4.811	– 0.725	– 0.060
75% Military	– 1.450	– 1.164	– 10.511	– 2.154
75% Economic	– 1.088	– 0.889	– 0.900	– 4.759

Test 9 results: This test was run to examine the effect of a changing the parameters of the proxy, to something that could be considered more realistic for the region in which the action took place. In theory, the player with the highest affinity would have the highest chance of being selected as proxy, at 65%, since it would follow that there would be fewer declines and more acceptances due to the higher affinity. A two-sample *t*-test, implemented as "Matched Pairs" in JMP (version 10), was run for each of the variables to test for a difference between the control group's mean value and the mean of the Test 9 group. (Note our comment on the underlying randomness above.) The results of these tests indicated that the averages of nearly all of the output variables are unchanged in Test 9, with the exception of the five interactive affinity terms. For the five interactive terms (target-hearer, requestor-region, hearer-region, requestor-target, and target-region) the mean affinity changes were all considered significantly different from the control group means. This was an expected result. However, unexpectedly, there was not a significant difference in the number of proxies accepted and declined.

Test 10: For this test the NW region was chosen arbitrarily. There was no difference in the mean values from the control group and the Test 10 group for the number of cancellations, action size or action impact. There was a slight decrease in permissions requested and accepted and proxies requested and granted, and a corresponding increase in permissions requested and declined and proxies requested and denied. This is more than likely due to the low affinity (–1 on a scale of –3 to 3) between the player and the NW region. With the higher number of denials and declines for permission and proxy actions, it would be expected that the player's affinity and influence would be lower and his hubris higher. This was not the case; hubris saw a tiny decline, while player influence and affinity both showed slight increases. It may be the case that the positive impact of the actions overshadowed the changes in affinity, influence and hubris that the denial and decline contribute to the respective values. Since the impact of actions continued to be generally positive for this test, it would be expected that there should be an affinity increase in the player-region and NPA affinities, and, indeed, the target-region, hearer-region, and player-region affinities all showed increases in the mean value of the new values over the starting values.

Test 11–14 results: These tests were conducted to evaluate the player's option to purchase modifier points in order to improve his or her chance of having the action selected be successful. In these tests we expect an increased average impact of the action with increased probability of selecting the option, which in turn should also improve the interactive affinity terms of the regions and the players. In Test 11 (in which no modifier was allowed) and Test 12 (in which the option was allowed 25% of the time), the expected decrease in the mean of the impact of action compared to the control group (in which the option was allowed 50% of the time) was observed. Conversely, in Tests 13 and 14 (in which the option's probability was 75% and 100% respectively) an increase in the mean impact of action value was seen; both were higher than the control group. Table 16 shows the results of JMP's "Matched Pairs" command when applied to the means of the control group and the test group. "No" indicates the difference was not statistically significant. Again, we present this as a guideline rather than as a probability statement about a particular null hypothesis.

Table 16. JMP results for matched pairs test and for varying the option modifiers

Test	Impact	Player Affinity	Requestor Region Affinity	Hearer-Region Affinity	Requestor-Target Affinity	Target-Hearer Affinity	Target-Region Affinity
No Modifier	No	No	No	No	No	No	No
25% Modifier	No	No	No	No	No	No	No
75% Modifier	Yes	Yes	No	No	No	No	No
100% Modifier	No	No	No	No	No	No	No

In the table, only two comparisons produced significantly different means. This is partially because often the simulations are unchanged between test and control group. Additionally, not all actions have a modifier option available, and if the player did not have sufficient resources, the option modifier, although approved, was not implemented in the dice roll. The values for permission, proxies and unilateral actions did not change from the control group. An additional item that changed was the increase in expenditure of DIME resources since this is how the option modifier is exercised. This test indicates that the option modifier, as implemented here, is not making a significant impact on the results of the game.

Tests 15–19: These tests involved changing the probability for proxies and permissions to determine if there is a significant impact on affinity and PMESII values. In the control group, actions in which permission was requested had it denied around 39% of the time. Among actions in which proxies were requested, 43% were declined. When only proxies and unilateral actions were allowed in Test group 15, the proportion of proxy requests declined average remained at 43%. In Test group 16, only permissions and unilateral actions were allowed. The average proportion of permissions that were denied increased slightly to 41%. In Test 18, only permissions were allowed and again the average of denials remained at 40%. In Test 19, where only proxies were allowed, the percentage of declined proxy requests was at 42% of all proxy requests. The big change came in the affinity between players and regions. In Test groups 15, 16, 17 and 18 mean target-hearer affinities all decreased from the control group mean values, whereas in Test 19, the target-hearer affinity increased. Mean requestor-region requestor-target affinities both showed increases with Test groups 16, 17 and 18 and decreases in Tests 15 and 19. Hearer-region affinity decreased in Test groups 16, 17 and 18 and increased in 15 and 19. Target-region affinities decreased in all test groups compared to the control group. These tests shows that the permission, proxy and unilateral actions do have an impact on the affinities. This test also shows that there is a built in proportional control in the underlying algorithms for permissions granted and denied and proxies accepted and declined.

Results Region PMESII values: Region PMESII values are a result of an extremely intricate infrastructure built into the game's artificial intelligence and includes spillover effects from other regions. The examination of Region PMESII could support an entire additional study on its own. Each action that occurs in a particular region not only results in changes in that region's PMESII values, but also in changes in the PMESII values of each of the other regions, through what is called association value. The SMEs determine these values in advance and based them on actual data from the regions. The association value represents the impacts of each region on each other (i.e., region one's impact on region two, region one's on region three, region two's on region one, etc.). These values, multiplied by an association weight value, are included in the region PMESII calculations. There is also an internal score that is determined by values (also obtained by SME) placed on the interactions between PMESII variables (i.e., Political effect on Political, Political effect on Military, etc.). These values, multiplied by an internal weight value and then combined with the association values, contribute to the calculation of the new region PMESII values following each turn. Essentially, every action, in any region, will establish 48 new PMESII values (one of each PMESII entry for each of eight regions). However, the changes in PMESII values of most interest are the ones in the action's region and we focus on those.

Table 17 is a snapshot of the table of new PMESII values for the NW region after an action. The Action was 312, which is a Military action (3), and the actual action is a large combat operation (12). The modified dice result was an eleven, which for this action is considered a success. The results of a successful combat operation on a region's PMESII are –12 in P, –8 in M, –16 in E, –30 in S, 0 in Info, and –12 in Infra. These are the repercussions of the actions, but they do not represent the sole effect on the PMESII. For each of the 1,000 simulation, these values are inserted into the region PMESII equation (see equation 5 of chapter 2) and Table 17 shows the resulting changes.

Table 17. Snapshot of new PMESII values after an action

Action	Result	Region	NW P	NW M	NW E	NW S	NW In	NW Ir
411	10	NE	–34.42	–52.61	–4.60	11.54	–7.40	–64.06
323	8	NW	–34.42	–52.61	–4.60	11.54	–7.40	–64.06
312	11	NW	–70.42	–19.60	–88.61	–78.45	–7.40	–94.06
48	12	SS	–34.42	–52.61	–4.60	11.54	–7.40	–64.06
32	14	NE	–34.42	–52.61	–4.60	11.54	–7.40	–64.06

The effects on PMESII remain the most impenetrable part of the model. Whether the PMESII values accurately reflect the changes in the region would require substantial additional investigation, perhaps by comparing the results of a real-world incident to a similar action in the simulation and observing how teach impacted the region. We have, however, provided a framework and starting point for such a study.

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V. CONCLUSIONS

In this work, we have greatly broadened the usability of the Green Country Model (GCM) so that it can be played without time-consuming and expensive human interaction. With our Java front-end the game can be run in thousandths of a second, rather than in the half-day currently required. This opens the door for future researchers to examine the relationships of input and outputs in the model, to evaluate the effects of changes in policy, starting values or other assumptions, to determine the distributions of outcomes under the randomness associated with the model, and if desired to seek the set of parameters that optimizes some result.

Overall the Green Country Model appears to work accurately, in that it reflects what the developers intended. Therefore, it can be an effective training tool. This war-game may accurately provide real-world insights about a society to game players (as long as the SME input is valid), and greatly assist in understanding the repercussions of an action, on numerous entities within a region. By rebuilding this board game into a computer model that can quickly simulate actions thousands of times, we can help the developers understand the impact of the enormous number of parameters built into the game, as well as the effects on the end results of adjusting these parameters. This model could also prove useful to the SMEs, who provide an immense amount of input data for the game, prior to the game commencing. SMEs could use simulations to test the validity and limitations of their input data by testing the upper and lower bounds and comparing the outputs to real-world events. This model is not meant to be used to predict the results of an action on a society; however, it can provide users and even policy makers information about the effects of an action, as well as the ability to change the probabilities of occurrence in every parameter in order to assist in finding the best course of action for a situation. While this type of model can never replace the decision-making process for leaders, it might be effectively used as a training tool, allowing users to flesh out ideas and narrow the available options towards a more successful end result.

The vast size and number of parameters in this model make it impossible to validate in one study. However, we believe that our study provides a good initiation into the validation process, and the framework developed could be utilized and built on, to run thousands of other simulation tests and continue the validation process. Throughout the research, possible adjustments and follow-on studies have been proposed; these should be investigated to understand how or whether they impact the game. As a specific example, our tests did not reflect a large enough impact of the option modifier for it to make any difference. Similarly, the proxy and permission mechanisms are complicated and sophisticated, but in our game play the actual effects on the affinities are small. This information may be useful to developers examining the role of these requests in the game.

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